MODERN

AGRICULTURAL IMPROVEMENTS:

BEING A

SUPPLEMENT

TO THE

BRITISH HUSBANDRY

OF THE

SOCIETY FOR THE DIFFUSION OF USEFUL KNOWLEDGE.

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PREFACE.

THIS little work is intended to include a detail of the chief modern practical improvements which have during the last few years, or since the publication of "The British Husbandry," served so much to promote—to elevate—and to adorn the Science of Agriculture. A lengthened experience of the kindnesses, which the noble Farmers of his country have so liberally showered over his efforts in their service, assures its Author, that This Volume will receive at their hands full as much favour as it deserves. To those old and staunch friends it is dedicated; and, if it only serves in any degree to smooth the path of the young agriculturist, the Essay will not have been written in vain.

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MODERN

AGRICULTURAL IMPROVEMENTS.

SECTION I.

THE HISTORY AND PROGRESS OF AGRICULTURE *.

The advances which have been made in the improvement of Agriculture since the first publication of this valuable work, are extensive and important. "Science" has been united with "practice," with a success and with a rapidity never equalled in any former period of its history. Fortunately, too, this onward march betrays, at present, no symptoms of having ceased: each season now produces the result of some new examinations, some valuable discovery, or important improvement, the natural result of the enlarged spirit and knowledge which have been so happily directed to the cultivation of the soil. It would be a gratifying and an instructive task, did our limits allow of so extensive a field of inquiry, to follow the quiet progress of agriculture during the last fourteen years; but such a research would occupy far too considerable a portion of our allotted space. It will ever be a gratifying retrospect for the farmers of this generation, to note how well the labours of the great leaders of agricultural advancement have carried on the great course of improvement which such men as the late Francis Duke of Bedford, Arthur Young, Sinclair, and Coke, so well and so laboriously headed. Such a reader will note, that the stream of steady improvement in England's agriculture did not cease when the grave closed over the last of these great names; since, when the late Earl of Leicester died in 1842, the Royal English Agricultural Society had been just originated. The labours of Lord Leicester, during nearly seventy years, have been well sketched (*Journal English Ag. Soc.* vol. i. p. 1) by another great farmer, the late Lord Spencer, to whom the farmers and the graziers of England are under very considerable obligations. The valuable efforts of the last years of Lord Spencer, to the period of his death in 1845, (*Farmer's Almanack*, vol. iii. p. 42,) are closely connected with that of the Royal Agricultural Society of England, whose history will ever be interesting to every friend of the improved cultivation of the soil. Amongst his earlier labours, too, we may state, on the authority of Lord Brougham, that he revised the whole of the MS. of the *British Husandry;* as well as the other volumes of the *Farmer's Series.*

It would be difficult, as I have elsewhere had occasion to remark, (*On Implements*, p. 8,) to name any other society whose progress in its early days will compare in rapidity and in success with that of the Royal Agricultural Society of England. An Institution whose formation was retarded long after the more than probable value of such a society to the agriculture of the United Kingdom had become apparent to many of its most enlightened farmers. This delay was chiefly owing to the

* *Supplementary Note, No.* 1, *for vol.* i. *p.* 28, *of* "*British Husbandry.*"

complete failure of the Board of Agriculture, which, established by the exertions of Sir John Sinclair, in 1793, and chartered by George III., was supported for nearly a quarter of a century by an annual grant. This, however, being withdrawn in 1817, with the support of Parliament terminated the Board of Agriculture; a fate little lamented by the farmers of our islands; for it made many mistakes, and was far too much mixed up with the politics of the day to possess the confidence of any but the party under whose banners it happened to array itself.

For many years, therefore, after the dissolution of the Board of Agriculture, there was not to be found in this country any national Society which in its objects and power could be compared to the great and successful Highland Society of Scotland. The first person who steadily and successfully exerted himself to form such a Society, was my friend Mr. William Shaw, a gentleman to whom in this, as in many other great efforts, agriculture is deeply indebted. On many occasions, during 1834 and the succeeding years, in more than one agricultural periodical, he suggested and advocated the establishment of a national Institution for the advancement of practical agriculture, and of practical agriculture only. He had also, to accomplish this object, several personal communications with Lord Spencer, the Duke of Richmond, Mr. Handley, and other great leading agriculturists, and, in consequence of these efforts, at the dinner of the Smithfield Club, on the 11th of December, 1837, Lord Spencer, in his address to the Club, suggested the establishment of such a Society; a suggestion which was warmly received by the meeting, and immediately responded to by the Duke of Richmond, Mr. Handley, Mr. E. W. Wilmott, and, in fact, by the whole party.

Lord Spencer remarked, (alluding to the Smithfield Club,) "Our Society in the metropolis is totally useless for the promotion of the general purposes of agriculture; but if a Society was established for agricultural purposes exclusively, I hesitate not to say that it would be productive of the most essential benefits to the English farmer. There is one point, however, which I must impress upon you in reference to the formation of a Society such as I have mentioned, namely, that there can be no prospect of our obtaining any useful results, unless politics, and the discussion of all matters which might become subjects of legislative enactment, are scrupulously avoided at its meetings." The Duke of Richmond expressed as his opinion, that "such an institution would promote agriculture, and confer great and inestimable advantages on every class of the community." Mr. Handley, when observing that he had long contemplated the formation of such a Society, very truly remarked that "there is not a single department of farming but what is capable of vast improvement."—(*Farmers' Magazine*, vol. viii. p. 48.)

A short time after this discussion, there appeared a very excellent pamphlet from Mr. Handley, dated from Culverthorpe, in January, 1838, entitled, "A Letter to Earl Spencer (President of the Smithfield Club) on the formation of a National Agricultural Institution:" In the course of this he very justly observed, (and the answer to his concluding question can only be made in one way,) "Great attention and expense, spirited emulation, and well-directed experiments, grounded upon scientific principles, have succeeded in producing that near approach to perfection in breeding and feeding cattle, which was so remarkable at the late Christmas Show. Why, then, should not the same combined efforts be united in the application of *science* to the sister art, agriculture, which your Lordship has justly pronounced to be still in its infancy?"

The public impression of the value of such a Society to the advancement of agriculture now became too general to fail of producing the expected results; and in the early part of the following month of March, an advertisement appeared in the public papers, to the effect, that several noblemen and gentlemen, "having observed the great advantages which the cultivation of the soil in Scotland has derived from the establishment and exertions of the Highland Society, and thinking that the management of land in England and Wales, both in the cultivation of the soil and in the care of woods and plantations, is capable of great improvement by the exertions of a similar Society, request that those who are inclined to concur with them in this opinion will meet them, on Wednesday, the 9th of May (1838), at the Freemasons' Tavern." To this were attached the signatures of the Dukes of Richmond and Wellington, the Earls Fitzwilliam, Spencer, Chichester, Ripon, and Stradbroke, Lord Portman, R. Clive, B. Baring, Sir James Graham, Sir F. Lawley, J. Bowles, E. Buller, R. A. Christopher, H. Blanchard, W. T. Copeland, J. W. Childers, R. Etwall, H. Handley, C. S. Lefevre, W. Long, W. Miles, J. Neeld, E. W. W. Pendarves, P. Pusey, E. A. Sandford, R. A. Slaney, J. A. Smith, R. G. Townley, W. Whitbread, and Henry Wilson.

In consequence of this address, on the 9th of May a very numerous and influential meeting was held, at which Earl Spencer presided, and at which, after some attempted interruption by one or two persons who did not exactly comprehend the objects of the proposed society, it was resolved, on the motion of the Duke of Richmond, seconded by Mr. Handley,—1. "That a society be established for the improvement of agriculture in England and Wales, and that it be called the 'English Agricultural Society.'" 2. On the motion of Sir Robert Peel, seconded by Mr. C. Shaw Lefevre, "That no question be discussed at its meetings, of a political tendency." 3. On the motion of Sir James Graham, seconded by Mr. W. T. Copeland, "That the society should consist of two classes, Governors and Members." 4. On the motion of Earl Fitzwilliam, seconded by Mr. P. Pusey, "That annual meetings be held successively in different parts of England and Wales." 5. On the motion of the Earl of Chichester, seconded by Mr. E. S. Cayley, "That a Committee be appointed to frame Rules and Regulations, and to report to a general meeting on the 27th of June." And it was finally agreed that all those who joined the Society before that day might become members of the Society; but that subsequently to that period they should be elected by the Committee.

The list of those who, by the 12th of May, or within three days of the Society's formation, were its members, is worthy of being preserved. It is a list which I have little doubt will long be a source of interest to the English farmer, for it contains the names of almost all those who, with Mr. Shaw, may be regarded as the founders of the Society.

IST OF SUBSCRIBERS TO THE ENGLISH AGRICULTURAL SOCIETY, MAY 12, 1838.

eland, Sir T., Bt.	Bagge, W., M.P.	Barnard, R.	Boys, H
deane, H. J.	Baker, J. W.	Barneby, J.	Boys, —
lston, R.	Barber, R.	Beach, Sir M. H., Bt.	Bouverie, E.
lmon, R. G.	Barclay, C.	Bevell, J.	Bramston, T. W.
mherst, Lord	Barclay, D.	Blachford, O.	Braybroke, Lord
ngerstein, J. J.	Baring, W. B.	Blake, —	Bridport, Lord
ntrobus, Sir E., Bt.	Barker, G.	Bland, W.	Bromwel, Rev. R.
rbuthnot, Rt. Hon. C.	Barker, J. R.	Blanchard, H.	Brookes, J.
rcedeckne, E.	Barker, T. R.	Bowes, J.	Bruges, W. H. L.

of the Southampton meeting inclusively, will show the corresponding relation of each of these particular heads of inquiry during the period of the Society's past history:—

	Members.	Income.	Expenditure.
1838 . . . / 1839 . . .	2172	£7446	£6941
1840 . . .	4262	5001	4040
1841 . . .	5382	6028	5150
1842 . . .	6500	6236	5699
1843 . . .	6903	7907	6906
1844 . . .	6827	9291	9070

Thus numerously supported, thus liberal in its disbursements for the advancement of agriculture, we need feel little surprised when we behold the harvest it has reaped. This may in some degree be noted in the steadily advancing science of the valuable papers which grace its journals; but in a still greater degree in the *spirit* which it has diffused, not only by its general course of proceedings, but in the local country meetings which it has held. "Though," very justly remarks Mr. Pusey, (*Jour. R.A.S.* vol. iii. p. 169,) "we could not be fairly required to have done much in so short time, we certainly ought to have done something, strengthened as we have been by the hearty aid of the English farmers;" and when speaking of the future, he adds, "We shall be more likely to advance farther, if we look at the difficulties we still have to deal with; and the best encouragement, perhaps, for active men, is the knowledge that they have still a great deal to do."

On the progress during the last fourteen years of the Smithfield Club, the value of whose splendid exhibitions to the steady and long-continued advance towards perfection of the now unrivalled breeds of our domestic animals, (which this great and practical society has so long and so successfully been the means of advancing,) the opinion of the farmers will be pretty harmonious. From the days of its first institution, from the time when the great Francis Duke of Bedford and Thomas William Coke were amongst its earliest members, and throughout the presidency of the late excellent and indefatigable breeder, Lord Spencer, it has mainly aided and accelerated the improvement of almost every description of live stock. It has been the means, not only of directing the attention of the leading breeders of the kingdom to the points the most desirable in a farmer's live stock, but it has done no mean service in elevating and improving, in this respect, the taste of the farmers throughout the kingdom. To the general reader, who can commonly distinguish but little difference in the real value of the varieties of the same animal, some idea may be formed of the advance of this great branch of agriculture, when he learns the progress made in their improvement during the last century. About the year 1740, the number of cattle sold annually in Smithfield Market amounted to about 80,000; but since 1840, they have averaged about 180,000. And not only have the sales increased in the *number* of the animals, but in their *quality*, and in their *condition*, for it has been shown that the average *dead weight* of the animals sold in this great market, which is now of the bullock about 656 lbs., of the calf about 144 lbs., of the sheep and lamb about 90 lbs., and of the pig about 96 lbs., hardly attained to *half* this *average weight* in the year 1730. And there is, moreover, no symptom yet apparent of the march of improvement in our breeds of live stock being stayed, or of the great English breeders feeling convinced that the utmost limits of per-

fection are now attained. "I do not," said Webb of Babraham, one of the greatest of modern sheep breeders; "I do not," he remarked at an agricultural meeting in 1846, "say that I shall *accomplish* still greater improvements in the sheep than any I have yet been able to make; but this I will promise you, that I am with great confidence and determination making the attempt." And when such a breeder as this so expresses himself, we may feel assured, that it is an idle and baseless conclusion to which some persons are so easily led, that the Smithfield Club can do little more for the improvement of our breeds of domestic animals. No, no; rather let such reasoners adopt the noble language not long since employed by another great English farmer, (in whose presence some person had complacently assured a public meeting that farming had now nearly, if not quite, attained to perfection,) and say with Grey of Dilstone, "Let no one speak of perfection in agriculture; rather let that noble lord be perfectly assured that the perfection to which he has alluded will certainly not be attained in our time." Let such be the spirit, such the long-continued noble bearing of the English farmer, and then we are quite sure that the onward march of improvement need never stay: one improvement will be the mere stepping-stone to another; enlarged views will merely increase the circle for still more valuable extensions: the boundaries of agricultural science, let the cultivator be assured, will ever recede before the advancing knowledge of mankind. (See *British Husbandry*, vol. ii. p. 1.)

SECTION II.

THE HIRING OF A FARM: ITS PUBLIC BURTHENS.

THE IMPROVED TENURE OF LAND*.

THE improved cultivation of the soil during the last fourteen years has rendered obsolete many of the barbarous restrictions and unnecessary covenants which incumbered the leases of bygone generations; the necessity for the introduction of a different system of cultivation, of far more capital, of more varied rotations, and more extensive permanent improvements to the soil, was certain to bring about this state of affairs. For instance, the ordinary claim to unexhausted improvements made by an outgoing tenant has been gradually and very materially extended, with equal advantage to the tenant and to the landlord. "Tenant rights," as they are sometimes called, although still varying in different districts, may be regarded as now pretty well according, in all the best cultivated districts of England, with the following account given by Mr. G. M. Williams, the agent of Lord Yarborough, of the present custom of North Lincolnshire. (*Jour. R. A. S.* vol. vi. p. 44.)

"The *usual* allowances in the north of Lincolnshire to outgoing tenants for unexhausted improvements are as follows:—

"*Bone-dust.*—This is considered to last for three years, and a tenant quitting in the spring of 1845 receives therefore two-thirds of the cost of what he put on in 1844, (one-third being supposed to be exhausted by his turnip crop,) and one-third of what he put on in 1843, of which he has had the benefit of the other two-thirds in the crops of that year and of 1844.

"Precisely the same principle is adopted in the following improvements, the only difference being the number of years which each is

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* *Supplementary Note, No. 2, to "British Husbandry," vol. i. p. 56.*

assumed to last, and which are as follows:—Marl or chalk, 7 years. Lime, 5 years. Clay, put on sandy land, 4 years, and on some estates 7 years, which is probably a fairer allowance.

"Draining with tiles or stone, when the tenant pays the whole cost, 7 years. This is, however, now a rare case, the usual practice being for the landlord to find the tiles. In this case the tenant has generally no allowance for putting them in if he has had a crop off the land, though he certainly ought to have a proportion of the cost, as it must often happen that the first crop will not pay for the labour of draining. It would probably be right to put this on the same footing as bones. Draining with sods or thorns, 4 years. This allowance, I believe, is not always made. Indeed this mode of draining is now not much practised.

"The tenant is also paid the cost price of the seeds sown the spring previous to quitting, and for the labour of sowing, &c., provided they are not stocked after the 1st of November, and have not been unfairly stocked before. When seeds are ploughed up for wheat the autumn previous to quitting, he is allowed for herbage until the end of the term; but it is not usual to allow anything on ploughing up clover-stubble for wheat, that being considered the crop which ought to follow clover as a matter of course.

"For naked fallow, on strong land, he is allowed for ploughing and all the labour performed, but not for rent or taxes, unless he paid for them on entry. The cost of seed and labour on corn sown for the incoming tenant is of course always paid by the latter.

"The tenant has the right to remove, or can claim to be paid for, any buildings put up by himself on 'bay stones,' where the buildings do not enter *into* the ground, but he cannot remove a building attached to the freehold, nor even claim an allowance for it except by special agreement. On some estates buildings are allowed for like other improvements on a term of 20 years.

"A tenant cannot break up grass-land without permission, nor sell any straw, hay, or manure. He is bound to keep the buildings, fences, gates, and ditches in good repair, and to leave them so.

"All these claims and matters are left to be settled by two arbitrators, one to be named by the outgoing tenant, and the other by the landlord or incoming tenant; and if they cannot agree, then by a third party, to be named by the arbitrators before they begin to act.

"These customs are all so well established on this estate, that it is quite unnecessary to insert them in the ordinary agreements for farms. They are also pretty generally followed through this part of the county, unless where modified by regular agreements.

"In addition to the allowances I have mentioned, a fresh one has just been established on this estate, having become desirable from the increasing importance of its subject. It is an allowance for oil-cake given to stock, which you are aware has a most important effect in improving the quality of the manure, though there is seldom much profit to be made from it on the stock itself. The allowance is based on the assumption that the manure is improved to the extent of half the value of the oil-cake consumed; but, to get a fair average as to both quantity and price, it is made to extend over the last two years, and the allowance is *two-sixths* of the cake used in the last year, and *one-sixth* of that used in the previous one; making together the half of a year's consumption. Oil-cake given to horses is excluded, as I conceive the benefit to their manure would be comparatively trifling, and an allowance for it would tend to make cake supersede the legitimate food of the horses in

the last year of a tenancy. Cake given to sheep in the field is also excluded. This decision has been come to after careful consideration and inquiry, partly on the ground that the benefit to the sheep is sufficient to make it worth while to give cake without regard to the manure, and partly from the greater difficulties attending the getting a correct account, and the increased liability to fraud."

An attempt has been recently made to give to these improved customs the force of a legal enactment, by the introduction of a bill in the session of 1847, afterwards, however, withdrawn, entitled, " A Bill for the Improvement of Agricultural Tenant-rights in England and Wales," the preamble of which very truly stated that " it is expedient, for the better security of farmers in the improvement of land, and for the consequent increase of produce therefrom, as well as of employment for farm labourers, to enlarge and extend the custom of agricultural tenant-rights, in accordance with the modern advance of husbandry."

The advancing knowledge of the age will do more than any act of the Legislature to abolish the unnecessary restraints upon the farmer which disfigure the old and rarely observed leases to which I have already alluded. For, as I have elsewhere remarked, (*Farmers' Magazine*, vol. xxv. p. 108,) in examining the covenants of such leases, it will be found that the principle is too often acted upon in a greater or a less degree, that it is politic to make the farmer stipulate to farm his land under one general, unvarying system—that he must not, in certain things, employ his own good sense; but in all cases, not especially provided for in his lease, cultivate his land according to the custom of the country, whether good, bad, or indifferent farming prevails.

By this covenant, if the farms of a district are *generally* under such a lease, it is evident, if *the covenant is ever strictly construed and complied with*, that no great improvement can be expected to take place in the practice of farming. No valuable discovery can possibly, in such a case, be adopted, since it is certain that the first cultivator who breaks away from the custom of the country, in adopting a modern improvement, is legally committing a breach of the covenants of his lease. It would be much better, I think, to substitute for " the custom of the country," the words " in a good and husbandlike manner;" and of this opinion was Lord Ellenborough, who, in giving judgment (*Legh* v. *Newett*, 4 *East*, 164), in a case involving a claim for a breach of covenant, observed, " *The custom of the country*, with reference to good husbandry, must be applied to the approved habits of husbandry in the neighbourhood under circumstances of a like nature; and perhaps a contract, to occupy an estate in *a good and husbandlike manner* simply, would have imposed the same duty on a tenant, because the same sort of evidence, drawn from the approved practice of the country, would have been brought forward to show what was good husbandry." The custom or usage need not, however, be one followed from time immemorial: it is sufficient if there be a general usage. The practice of the country, and the good and correct feeling of English juries, it is true, causes generally substantial justice to be done to the farmer; but it is the true and wise object of all leases to avoid all causes of appeal to courts of law. Thus, even in a case where there was a written agreement, the court held that a custom of the district for the tenant to carry off the waygoing crop might be enforced; for, as the great Lord Mansfield remarked in giving the judgment of the court, " The custom is good, it is just; for he who sows ought to reap, and it is for the benefit and encouragement of agriculture. It is, indeed, against the general rule of

law concerning emblements, which are not allowed to tenants who know when their term expires, because it is held to be their fault or folly to have sown when they knew their interest would expire before they could reap; but the custom of a place may rectify what would otherwise be imprudence or folly." (*Wigglesworth* v. *Dallison*, 1 Douglas, 201.)

Let, therefore, the contracting parties to a farm lease make it as clear, as brief, and as certain as they can; for uncertainty is ever the mother of contention and discomfort; but do not let them endeavour to contract to do more than is compatible with the ever-altering circumstances and improving practice of agriculture.

Mr. Hewett Davis, (himself a tenant-farmer,) as land-agent to very extensive estates, extending over a variety of soils, and in different counties, has adopted very reasonable general covenants, which I will give, making certain observations as I proceed. He says, (*Ag. Gaz.*, vol. iii. p. 394,) when speaking of those leases, and their covenants, which he generally employs for arable farms:—

"1. *The Term.*—21 years, but determined by either bankruptcy, insolvency, non-payment of rent, or breach of covenant.

"2. *Rent.*—Tenants to pay the rent QUARTERLY, and discharge all taxes, tithe, rates and impositions, except the land and the property taxes, which are allowed out of the rent. [The covenant to pay the rent quarterly does not oblige the landlord to *collect* the rent quarterly; he may still receive it when he pleases. It is stipulated to be paid quarterly, because, in case of non-payment or other breach of covenant, it facilitates the necessary legal proceedings.]

"3. *Repairs.*—The tenant to do all repairs. Landlord to find timber, CUT OUT FOR CARPENTERS' USE. Tenant to cart, and pay for cutting out the timber. [The more common practice of allowing *rough* timber for repairs, is an unnecessary loss to the landlord, inasmuch as a large proportion of a marked tree is commonly unsuited to the tenant's use, and therefore a loss to the landlord.]

"4. *Cropping.*—The land to be so cropped that, as near as can be, never more than three-fifths at once shall be cropped with corn, and that the remaining two-fifths shall be fallow, or under turnips, green tares, mixed grasses or clover, or roots for the feeding of stock; and that two cereal crops of corn shall never be grown in two successive years on the same ground.

"5. *Exchange for Manure.*—That for all hay, straw, roots, or fodder, green or dry, taken off the farm, double the quantity of animal excrement shall be returned; and the tenant, at Michaelmas of each year, shall furnish in writing an account of all that has been taken away, giving the dates, names, and addresses of the purchasers, and the quantities of each delivery, and of all the manure brought back, giving the dates, names, and addresses of the vendors, and the quantities purchased in return during the past year. [The legislature of England has, on more than one occasion, endeavoured to carry out the great object of all wise governments, the good progress of practical agriculture. Thus, by the 56 Geo. III. c. 50, s. 1, it is enacted, that no sheriff or other officer shall sell or carry off from any lands, any straw, chaff, or turnips, or manure, in any case, nor any hay, or other produce, contrary to a covenant or written agreement. And, by a subsequent section of the same act, it is provided that the assignees of a bankrupt or insolvent shall not take any crop, or hay, straw, or manure, in any other way than the bankrupt would have been entitled to.]

"6. *General Covenants.*—The tenant shall maintain the land in a

clean and husbandmanlike condition, preserve the timber and hedges from waste or injury; keep clean all ditches, watercourses, and drains; repair, and keep in good repair, all buildings, erections, gates, stiles, fences, and roads; and generally protect and uphold all rights and privileges attached to the farm.

"7. *Out-going Tenant.*—Shall leave all the hay, oats, and straw, of the last year's growth, save what may have been consumed on the premises, for the incoming tenant to take by valuation at a feeding price. To be allowed, gratis, the use of the barns and stackyards, and all necessary convenience, for the purpose of thrashing out the corn not taken by the incoming tenant, and getting it to market, for six months after the expiration of his tenancy.

"8. *Game.*—To belong (except hares and rabbits) to the landlord.

"9. *The Landlord.*—To insure; to give quiet enjoyment; to pay the tenant at quitting (less all arrear of rent, rates, tithe, taxes, and other charges upon the farm up to Michaelmas-day) the amount of the appraisement which shall be due to him, according to the subject-matters of the one paid at entering, the same to be ascertained by the time of quitting by two appraisers, or their umpire, who shall be nominated a month prior to the time of quitting; and in case either party shall neglect to appoint an appraiser (or an umpire in case of difference between the appraisers) then the valuation shall be made by the single appraiser, or the umpire nominated by one party."

It will be perceived that in this substance of a lease no provision is made for the allowance to the out-going tenant for his growing crops, tillage, or manure. This is omitted by Mr. Davis, from the conviction that these ought to belong to the *landlord*, and that in the more ordinary practice the amount of these valuations add very materially and injuriously to the necessary capital of the farmer. I see very clearly the advantages of Mr. Davis's plan, in this respect, but I doubt its extensive applicability.

To such efforts, then, to improve and simplify the tenure by which the farmer holds his land, let every landowner direct his attention; and let him do this not only for the good of the tenant, but for the increasing value of his own estate. It is idle to conclude that the old forms of leases will longer suffice in this respect: even the legislature have given pretty clear indications of their opinions in this respect, and by the 8 & 9 Vict. (1845) c. 124, the landowner will see in the form of a lease there given (for general purposes), in how few words a legal demise may by the aid of that act be now made.

TITHES*.

The general commutation of tithes has since been carried into effect by the 6 & 7 Will. IV. c. 71, entitled "An Act for the Commutation of Tithes."

POOR LAW†.

The entire system of administering the Poor Law has been since altered by the 4 & 5 Will. IV. c. 76, and subsequent acts. By this act the management of the poor throughout England is transferred to Commissioners, who are styled "the Poor Law Commissioners of England and Wales," and are authorized to appoint and delegate their powers to Assistant Commissioners.

* *Supplementary Note, No. 3, for vol.* i. *p.* 82, *of* "*British Husbandry.*"
† *Supplementary Note, No. 4, for vol.* i. *p.* 83, *of* "*British Husbandry.*"

The following Table, constructed from a Parliamentary Return, will afford the reader a pretty accurate view of the general result of the operation of the Poor Laws, and of the collective and individual burthens which they entail upon the community. (*Parl. Paper*, 1846.)

Years.	Population of Great Britain.	National Debt.	Interest on National Debt, Funded and Unfunded.	Amount of County Rates.	Amount of Poor's Rates in England.	Number of Paupers in England.	Average Price of Wheat per Quarter.		Average ratio which the Amount levied for Poor's Rates, &c., bore per head on the Population in England and Wales.	
	No.	£	£	£	£		s.	d.	s.	d.
1796	. . .	301,861,306	11,841,204	229,390	. . .	. . .	76	3		
1797	. . .	355,323,774	14,270,616	247,009	. . .	. . .	52	2		
1798	. . .	414,936,334	17,585,518	268.666	. . .	. . .	50	4		
1799	. . .	423,367,547	17,220,983	289,231	. . .	. . .	66	11		
1800	. . .	447,147,164	17,381,561	292,280	. . .	. . .	110	5		
1801	10,942 646	447,043,489	19,945,624	326,130	. . .	. . .	115	11		
1802	11,109,367	522,231,786	19,855,588	317,977	. . .	. . .	67	9		
1803	11.276,088	528,260,642	20,699,864	286,055	5,348,205	. . .	57	1		
1804	11,442,809	545,803,318	20,726,772	298,653	. . .	. . .	60	5		
1805	11,609,530	573,529,932	22,141,426	325,098	. . .	. . .	87	1		
1806	11,776,251	593,694,287	23.000,006	338,685	. . .	. . .	76	9		
1807	11,942,972	601,733,073	23,362,685	366,564	. . .	. . .	73	1		
1808	12,109,693	604,287,474	23,158,982	350,128	. . .	. . .	78	11		
1809	12,276,414	614,789,091	24,213,867	393,322	. . .	. . .	94	5		
1810	12,443,135	624,301,396	24,246,946	436,447	. . .	. . .	103	3		
1811	12,609,864	635,583,448	24,977,915	497,027	. . .	. . .	92	5		
1812	12,788,040	661,409,958	25.546,508	502,223	. . .	. . .	122	8		
1813	12,966,216	740,023,535	28,030,239	548,174	8,646,841	1,426,065	106	6	17	0
1814	13,144,392	752,857,236	30,051,365	573,504	8,388,974	1,402,576	72	1		
1815	13,322,568	816,311,940	31,576,074	541,890	7,457,676	1,319,851	63	8		
1816	13,500,744	796,200,196	32,938,751	557,963	6,937,000	. . .	76	2		
1817	13,678,920	776,742,403	31,436,245	566,529	8,128,000	. . .	94	–		
1818	13,857,096	791,867,314	30,880,244	646,466	9,320,000	. . .	83	8		
1819	14,035,272	794,980,480	30,807,249	658,456	8,932,000	. . .	72	3		
1820	14,213,448	801,565,310	31,157,846	698,868	8,719,655	. . .	65	10		
1821	14,391,631	795,312,767	31,955,304	672,054	8,411,893	. . .	54	5		
1822	14,589,069	796,530,144	29,921,493	615,298	7,761,441	. . .	43	3		
1823	14,786,507	791,701,612	29,215,905	577,446	6,898,153	. . .	51	9		
1824	14,983,945	781,123,222	29,066,350	568,536	6,836,505	. . .	62	–		
1825	15,181,383	778,128,265	28,060,287	673,393	6,972,323	. . .	66	6		
1826	15,378,821	783,801,739	28,076,957	736,099	6,965,051	. . .	56	11		
1827	15,576,259	777,476,890	28,239,847	731,772	7,784,352	. . .	56	9		
1828	15,773,697	772,322,540	28,095,506	723,197	7,715,055	. . .	60	5		
1829	15,971,135	771,251,932	29,155,612	691,266	7,642 171	. . .	66	3		
1830	16,168,573	757,486,997	29,118,858	708,007	8,111.422	. . .	64	3		
1831	16,366,011	754,100,549	28,341,416	754,996	8,279,217	. . .	66	4	12	0
1832	16.595,051	751,658,883	28,323,751	761,901	8,622,920	. . .	58	8		
1833	16,824,091	743,675,229	28,522,507	759,354	8,606,501	. . .	52	11		
1834	17,053,131	751,658,883	27,783,454	723,741	8,338,078	. . .	46	2		
1835	17,282,171	743,675,299	28,403,305	671,082	7,373,807	. . .	39	4		
1836	17,511,211	758,549,866	28,533,192	705,248	6,354,538	. . .	48	6		
1837	17,740,251	761,422,570	28,524,739	638,047	6,294,566	. . .	55	10		
1838	17,969,291	762,275,188	28,585,503	683,865	5.186,389	. . .	64	7		
1839	18,198,331	761,347,690	28,748,794	741.407	5,866,000	. . .	70	8		
1840	18,427,371	766,541,680	28,556,324	679,291	6,014,605	1,199,529	66	4		
1841	18,656,414	766,371,725	28,701,458	679,324	6,351,828	1,299.048	64	4	8	1
1842	18,885,454	774,319,913	28,609,709	703,526	6,552,890	1,427,187	57	3		
1843	19,114,494	773,068,340	28,516,882	. . .	7,085,595	1,539,490	50	1		
1844	19,343,534	769,193,644	27,839,245	. . .	6,848,717	. . .	51	3		
184[illegible]	19,572,574	768,789,241	27,827,265	. . .	. . .	. . .	50	10		
184[illegible]										

SECTION III.

THE CULTIVATORS OF THE LAND.

THE LABOURERS OF AGRICULTURE *.

The condition of the agricultural labourer, to which the "British Husbandry" so well aroused the public attention, has since steadily, and with a considerable measure of success, engaged the laborious efforts of many benevolent persons. The Royal English Agricultural Society directed its attention to the same important question; and by the New Poor Law Act many improvements have been attained in the better management of the poor. The wages of the rural labourer can no longer be entirely, or even partially, paid out of the poor-rates. The accomplishment of this great object, if they had no other claims to the gratitude of the country, would alone entitle the labours of the original framers of the bill to no inconsiderable meed of praise. During these researches many facts have been ascertained, many laboriously procured details have been arranged, which, reduced to a tabular form, have aided in the success of past efforts, and will still materially assist the future labours of those who are yet anxiously endeavouring to still further elevate in the scale of society, and increase the comforts of the invaluable labourers in agriculture; a class who, from their generally retired, quiet, unassuming habits, have never received that general share of attention to which they are so fairly entitled. Few persons are aware even of the amount of the large number of these rural labourers dispersed throughout the island. The following return shows the number of males above twenty years of age so engaged in 1841:—

	Total Population.	Farmers and Graziers.	Gardeners, Nurserymen, and Florists.	Agricultural Labourers.	Total.
England ...	15,000,154	194,596	42,364	724,625	961,585
Wales	911,603	31,807	1,141	47,447	80,395
Scotland ...	2,620,184	50,732	5,727	109,550	166,009
Army and Navy.....	188,453				
Total........	18,720,394	277,135	49,232	881,622	1,207,989

The *proportion*, in numbers, which these bear to the commercial and miscellaneous classes of the British Empire, at different periods, calculated from the public returns, is shown by the following Table, (*Alison's England in* 1815 *and* 1845, p. 19):—

	1811.	1821.	1831.	1841.
Agricultural......	35	33	28	22
Commercial	44	46	42	46
Miscellaneous ...	21	21	30	32
Total Population	12,609,864	14,391,631	16,366,011	18,656,414

The wages of the agricultural labourer naturally varies with the de-

* *Supplementary Note, No,* 5, *for vol.* i. *p.* 116, *of* "*British Husbandry.*"

mand for and the supply of labour, (not, perhaps, so much as in the case of other classes of labourers,) and with the price of food.

Mr. Bacon has given the average price of wheat received per coomb (four bushels) and the labourers' weekly wages, from 1804 to 1844, on a light land Norfolk farm (*Survey*, p. 144):—

Date.	Wheat.	Wages.	Date.	Wheat.	Wages.	Date.	Wheat.	Wages.	Date.	Wheat.	Wages.
	s. d.	*s. d.*		*s. d.*	*s. d.*		*s. d.*	*s. d.*		*s. d.*	*s. d.*
1804	22 5	8 0	1814	32 0½	10 0	1824	29 4	9 0	1834	23 4	9 0
1805	46 4	10 0	1815	31 6	10 0	1825	32 4	9 0	1835	20 0	9 0
1806	30 5	9 0	1816	33 1	10 0	1826	29 0	10 0	1836	21 0	9 0
1807	35 6	9 0	1817	53 2½	12 6	1827	28 0	10 0	1837	26 0	10 0
1808	32 6	9 0	1818	41 5½	10 6	1828	30 0	10 0	1838	34 6	11 0
1809	46 9	10 6	1819	35 10	10 6	1829	32 6	10 0	1839	32 4	10 6
1810	50 0	12 0	1820	32 9	10 0	1830	31 0	10 0	1840	31 6	10 6
1811	41 6½	10 0	1821	28 1½	9 0	1831	33 0	10 6	1841	30 0	10 6
1812	60 0½	15 0	1822	19 11	8 0	1832	30 0	10 6	1842	26 0	10 0
1813	55 4	13 6	1823	24 6	9 0	1833	28 6	10 0	1843	24 0	9 0

The amount, *per acre*, of the labour bestowed upon the land is not only much more considerable than is commonly supposed, but that amount of labour has been long and steadily increasing. In fact it forms (fortunately for the labourer) one of the chief and most remunerative items in the amount of the farmer's capital bestowed upon the land. In the same valuable survey of Norfolk from which I have just quoted, Mr. Bacon has given, in the following table, the average amount of labour, *per acre*, on a farm in West Norfolk, in periods of five years, from the year 1785. (*Bacon's Survey of Norfolk*, p. 145.)

	s.	*d.*		*s.*	*d.*
13 years, ending in 1785	6	9	5 years, ending in 1815	22	4
5 „ „ 1790	7	2	5 „ „ 1820	23	9
5 „ „ 1795	8	2	5 „ „ 1825	21	0
5 „ „ 1800	11	0	5 „ „ 1830	24	0
5 „ „ 1805	15	6	5 „ „ 1835	23	2
5 „ „ 1810	19	6	5 „ „ 1840	26	7

Some persons may regard these charges as stated too high; but if we visit the opposite side of the kingdom, we shall find that on the richer soils of Gloucestershire the amount of labour applied to the soil is even much greater than upon the sandy lands of Norfolk. Mr. J. Morton has given this with his usual accuracy, (*Ag. Gaz.* vol. ii. p. 261,) and the following table of the results of his researches may be perused with advantage by even those political economists who fancy that the expenses of farming bear but a small proportion to its profits:—

CHARACTER OF DISTRICT.	Labour.		Profit.		Rent.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
Alluvium	12	7	14	9	46	0
Gravel	21	1	16	0	36	0
Bathstone	37	2	14	0	17	0
Lower oolite	35	7	16	0	25	0
Marlstone	44	1	15	0	38	0
Lias	11	10	12	0	20	0
New red sandstone	45	3	15	0	32	0
„ „ marl	18	3	14	0	28	0
Magnesian limestone	61	0	20	0	35	0
Coal clay	31	9	13	0	18	0
„ Pennantstone	55	0	19	0	30	0

CHARACTER OF DISTRICT.	Labour. s.	d.	Profit. s.	d.	Rent. s.	d.
Millstone grit	21	4	14	0	26	0
Mountain limestone	33	6	16	0	30	0
Old red sandstone	25	7	16	0	30	0

In 426 parishes, in the county of Norfolk, from whence, in 1831, returns were obtained, it appeared that the total number of labourers, men and boys, employed upon 100 acres of land *of all kinds* is 3½; upon 100 acres of *arable*, nearly 5, or 1 for every 20 acres. (*Sir J. P. Boileau, Journ. Stat. Soc.* vol. viii. p. 360. See *British Husb.* vol. i. p. 122.)

The prices for *piece* work, in the same great agricultural county, at the present period, is nearly according to the following scale. (*Farmer's Almanack*, vol. ii. p. 235.)

	s.	d.		s.	d.
	Per Acre.				
Mowing Wheat	5	0	to	7	0
,, Upland Grass	1	8	to	2	4
,, Meadow Grass	2	6	to	3	0
Hoeing Turnips, scraping between the drills	1	6	to	1	9
,, ,, cutting out	2	4	to	2	8
,, ,, scouring	2	6			
,, ,, picking	1	0			
,, Wheat	2	3	to	3	0
Dibbling Wheat	6	0	to	8	0
,, Beans	4	0	to	6	0
	Per Coomb.				
Thrashing Wheat by flail	1	4	to	2	0
,, Barley	0	10	to	1	4
,, Oats	0	6	to	0	7
,, Peas	0	8			
,, Beans	0	7			
	Per 20 Loads.				
Filling and spreading Clay	4	0	to	5	0
,, ,, Muck from Farm Yard	2	0	to	2	3
Turning over Muck-heaps	1	4	to	1	6

The labourer's daily wages in harvest time are always very considerably increased. The following table gives the amount which they generally received in various periods (*ibid*). (See *British Husbandry*, vol. i. p. 116.)

	s.	d.		s.	d.
In 1350	0	1	In 1740	0	10
1460	0	2	1760	1	0
1568	0	4	1788	1	4
1632	0	6	1794	1	6
1688	0	8	1800	2	0
1716	0	9	1840	3	0

In calculating the fair amount which the farm labourer is entitled to receive for his work, we too seldom regard in our estimates the drawbacks to which that labour is subject in the shape of sickness. The following table shows the average annual sickness of the labouring classes, expressed in weeks, from which we shall see that this loss (although less than in the case of the citizen) is very considerable. (*Jour. Stat. Soc.* vol. viii. p. 328; *Farmer's Almanack*, vol. iii. p. 15.)

Ages.	Rural Districts.	Town Districts.	City Districts.	Ages.	Rural Districts.	Town Districts.	City Districts.
20	·8387	·8564	·5659	55	2·3260	3·3029	3·3036
25	·8630	·8649	·9650	60	3·8531	4·9132	4·4973
30	·8753	·8794	1·1059	65	7·6305	9·1387	5·9019
35	·8991	1·0114	1·2372	70	14·1949	15·4995	9·9610
40	1·0677	1·2669	1·4663	75	20·7848	24·0134	22·3864
45	1·2537	1·8323	1·8125	80	24·3545	32·9841	35·2065
50	1·5896	2·5559	2·3831				

It is certain, too, that the amount of sickness and mortality materially increases with the price of corn. An endeavour has been made to show this from the amount of annual burials in England, compared with the prices of corn. (*Ibid.* vol. ix. p. 165.)

Years.	Windsor Prices.	Corn Return.	Burials in England.
1798	54*s.* 0*d.*	50*s.* 3*d.*	187,531
1799	75 8	67 6	189,586
1800	127 0	113 7	208,063
1801	128 6	118 3	204,434
1802	67 3	67 5	199,889

And in order to attempt to distinguish between the effects of high prices, on a mixed manufacturing and agricultural district and the entire kingdom, the following table gives the annual mortality of males and females in a population of 100,000, compared with the average prices of wheat in England and Wales, and the prices of meat, and the rates of wages paid at Greenwich Hospital. (*Jour. Stat. Soc.* vol. ix. p. 174.)

Years	1838		1839		1840		1841		1842		1843		1844	
In England and Wales . .	2240		2187		2290		2160		2167		2120		2155	
In Lancashire and Cheshire	2568		2843		2957		2541		2526		2491		2386	
In Yorkshire	2161		2317		2333		2164		2158		2113		2058	
Price of Food.	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Average price of Wheat .	64	7	70	8	66	4	64	4	57	3	50	1	51	3
Price of Meat per cwt. at Greenwich Hospital . .	42	5	47	8	54	0	56	1	52	9	40	1	40	10
Wages given at G. H. per Day.														
Bricklayers	4	9	4	9	4	9	5	3	5	3	5	3	5	3
Masons	5	3	5	3	5	3	5	5	5	5	5	5	5	5
Plumbers	5	5	5	5	5	5	5	9	5	9	5	9	5	9
Carpenters	5	5	5	5	5	5	5	8	5	8	5	8	5	8

In regarding the best means of adding to the comfort and elevating the condition of the agricultural labourer, let me repeat a few of the observations upon what, in another place, has been remarked more at length on the rural cottages and gardens (*On the Cottages of the Agricultural Labourers, by Johnson and Cresy*, p. 5); for the domestic condition of these, it can never be too often repeated, exerts a far greater influence, for good or for evil, than is generally understood.

THE LABOURER'S COTTAGE.

It is almost impossible, in any district, to examine the cottages in which the poor reside, without being convinced of the utter disregard of health and comfort very generally evinced in their construction. The site, their drainage, the size of their rooms, their ventilation, are in too many instances alike disregarded. The constructors of these, it is true, have produced "a cottage;" but it would seem that there all their care

terminated—the tightness of the walls, the dryness of their floors, the ventilation of their rooms, the size of these, the healthiness of the soil on which they rest, the sheltered situation and aspect of the house, the removal of sewage, being facts which never seem to have presented themselves for the builder's consideration. If cottages were to be built, it seemed as if, in his opinion, it sufficed if they were placed in situations where labour was needed and the ground cheap. The nature of that ground, whether well elevated above, or near to the level of stagnant waters, or other disease-producing localities, is too commonly, to such persons, quite immaterial. And yet the shortsightedness of thus acting seems most extraordinary: the fevers thus produced, the expense consequently often entailed upon the employer of the tenant dwelling in such houses, we might reasonably conclude would prompt all owners of cottages to be more attentive to avoid such errors. That these are not imaginary consequences of the neglect to which I have alluded, every medical man can bear testimony. "We would refer, in the first instance," said her Majesty's Commissioners, appointed to inquire into the health of towns, in their first Report, p. 10, "to the evidence of Dr. N. Arnott and Dr. Southwood Smith, who have stated to us the results of their continued and latest observations; and also the evidence of Dr. Guy, Dr. Aldis, Dr. Rigby, and Mr. Toynbee, who have had extensive practice in hospitals and dispensaries. This evidence, with that of Mr. Ward, displays their opinion and experience, that defective drainage, neglect of house and street cleansing, ventilation, and imperfect supplies of water, contribute to produce atmospheric impurities which affect the general health and physical condition of the people, generating acute, chronic, and ultimately organic disease, especially scrofulous affections and consumption, in addition to the fevers and other forms of disease to which public attention has been directed by previous sanatory inquiries."

THE COTTAGER'S GARDEN.

Of the advantages derived by the labourer from the possession of a garden it is hardly necessary to speak. In a work published last year, expressly for the use of the working classes, it is truly enough stated that the possession of a quarter of an acre of garden-ground may, and often will, make to the labourer and to his family the difference between want and sufficiency, between privation and comfort, between a contented mind and the cheerful fulfilment of the duties of his station, and a mind soured, hardened, and dissatisfied, prepared to yield to vicious promptings, and to rush recklessly into breaches of the law. (*The Farmer, by Charles Knight.* See also *Nowell's Manual of Field Gardening, and British Husbandry*, vol. ii. p. 557.)

"The size and situation of the garden," remarks Mr. Nicholl, in a valuable essay, to which I refer the farmer and the landowner, (*Jour. R. Ag. Soc.* vol. vii. p. 20,) "must, of course, depend very much upon local circumstances. It ought not, however, in any case to be so large as to interfere with the labourer's regular occupation, or withdraw him from his every-day pursuits; and from a quarter of an acre, according to circumstances, would, I think, be generally sufficient. With a garden of a quarter of an acre, the labourer can keep a pig, which the refuse vegetables from his garden will enable him to rear and nearly support. He may also keep bees, the value of which is well known to the thrifty housewife. These will serve as helps, and enable his family to enjoy many little comforts which otherwise they would be unable to obtain; and if, in addition to his garden, the labourer were to be allowed a bit

of land in the corner of a field to raise his potatoes, and a little milk for his children from the farmer's dairy, it would be of the greatest use to him, without being missed by his employer."

To such researches as these let me earnestly direct the farmers' attention. I know the readiness with which they engage in any little plan which tends to the comfort of those around them, and that they are not wont to be backward, even on the often correct plea that they cannot always effect so much good as they wish. "Let us not," once observed to me a noble Hampshire farmer, "say as an excuse for our idleness, that 'we can do but little;' rather let us do that little."

COTTAGE FARMING.

I cannot add anything to what I some time since had occasion to remark (*Farmers' Encyclo.*) on the advantages derived by the enclosure of waste land, and its cultivation by cottagers:—

"By the erection of small, comfortable cottages on the poor waste lands of our island, and the allotment to each of a few acres of land, a field is opened for the rapid recovery by the spade of barren lands, and the profitable employment of the landowner's capital, too little understood. By merely deepening and mixing the soil, the cottager can bring into cultivation lands which seem to defy all the powers of even the subsoil plough. This is a noble, a national theme, on which too much can hardly be said. I implore the owners of the wastes to consider, to calculate, and to make the experiment. Let them read the Report, by Provost Baillie, 'Of the system of improvement followed on the muirs of Drumforskie, now called Charleston, in the county of Kincardine, by the settlement of crofters on improving leases, with allotments of a few acres of waste land to each.' (*Trans. of High. Soc.* vol. v. p. 97.) The result, 'at the expiry of the leases, the whole will produce on 357 acres, an actual, permanent, and sure revenue of 750*l.* per annum.' (*Ibid.* p. 116.) And also let me refer the landowner to a paper on the Settlement of Crofters, by Mr. Thompson, and on the same noble effort by Colonel Fraser (*ibid.* pp. 379 and 387); and to the *Quar. Jour. of Agr.* (vol. v. p. 531) on the cotters who cultivate even the mountains of Switzerland, and the most naturally barren steeps of China. And if they set about the good work in earnest, then let them read the excellent essay of Mr. Blacker, '*On the Improvement to be* made in the Cultivation of Small Farms.' But this is not an attempt to be made without consideration. With care, it works admirably, diffusing comfort and gladness; but without some attention to the means and instruction of the little farmers, instead of producing a race of bold and happy cultivators, adding out of the mere waste to the riches of their country, it would only be the means of colonising the land with paupers." —(See *British Husbandry*, vol. i. p. 253.)

SECTION IV.

THE INCLOSURE OF LAND.

THE HEDGES, AND HEDGEROW TIMBER*.

As I have elsewhere had occasion to remark, (*Bell's Messenger*, No. 2,609,) there are few efforts more likely to be attended with good prac-

* *Supplementary Note, No. 6. See "British Husbandry," vol.* ii. *p.* 534. 552

tical results to the farmer, than the improvement and reduction of amount of his hedges and hedgerow timber. In many counties, the unnecessary extent to which these are allowed to exist, is an observation which forces itself strongly upon the attention of the farmer from better-managed districts. This error, there is no doubt, originated at a very early period of English farming. The hedgerows of the old manor farms and halls, especially those occupying the better varieties of land, are commonly remarkable from their irregularities and breadth; and it is here, too, that the timber of the hedgerows generally crowds the farmer's fields. The first English landowners, in fact, seem to have carefully and exclusively directed their attention to the naturally fertile portions of their manors; they followed, therefore, far too closely the irregular boundaries of these with their hedgerows and ditches; they very readily left the poorer portions of the land to the cattle of their commoners, or, as they were afterwards called, copyholders. It is but of recent date that the attention of the farmer has been drawn to the losses he sustains from the continuance of these drawbacks upon the productiveness of the soil. The example, however, was successfully set a few years since by Mr. John Morton, in the removal of the hedgerows and the hedgerow timber of Whitfield Model Farm, in Gloucestershire, a county which, in many places, is by far too much overgrown with timber. Through his courageous attempts, and his arguments, the bad system of fencing, too general in England, has of late gradually attracted attention.

In no district, perhaps, are the losses sustained by the farmer, from the unnecessary extent of hedgerows, greater than in the naturally richest portions of the county of Devon; producing, says Mr. J. Grant, (*Jour. R. A. S.* vol. v. p. 421,) a baneful effect, which adds so much beauty to the scene, at so great a cost to the landlord and tenant. "Look," has exclaimed to me more than one intelligent Devon farmer, "at what I lose from the shade of these hedges and trees, besides what they actually occupy. For nearly a ridge wide on either side, the corn is hardly worth reaping." The landlords of that county can surely not be generally aware of the extent of these hedgerows. Let them carefully consider the results of Mr. Grant's survey; let them, for instance, follow him through the parish of Huxham, which contains in 762 acres (the extent of the parish) 34 miles of hedgerow, occupying 54 acres of land, or 1 acre in 14 of the whole parish; or, let them ride through the parish of Broadclyst, containing 9,188 acres; here they will find 383 miles of hedge, occupying 613, or 1 in every 15 acres. The result of the examination of *ten parishes*, containing 36,976 acres, is, that in these Devon parishes *there are* 1,651 *miles of hedge*, or fence, which is about half as long again as the great wall of China, and sufficient to extend round the whole of England. The small *size* of these Devonshire inclosures (and the observation is applicable to many other districts) is most remarkable. In these 10 parishes there are 815 fields not exceeding from half an acre to one acre in extent; 1,347 between one and two acres; 1,293 between two and three acres; 1,220 between three and four acres; 1,015 between four and five acres; 743 between five and six acres; 511 between six and seven acres; 357 between seven and eight acres; 231 between eight and nine acres; 148 between nine and ten acres; and only 327 above ten acres. By the kind of hedgerows generally used, too, the loss of land is enormous; on those fields averaging three quarters of an acre, the loss by hedges is 17 per cent. of the whole estate; on those averaging between one and two acres, it is 10

per cent.; on those between two and three acres it is 12 per cent.; and even on fields of ten acres it is 4 per cent.; the per-centage, of course, varying considerably with the shape of the field, and the thickness of the fence.

Unfortunately the mischief arising from the existence of these unnecessary hedgerows is not confined to the extent of the ground they occupy. They not only shelter all kinds of birds and vermin, but they serve as nurseries for every description of weed; they prevent the free circulation of the air and the access of the sun's rays. They consequently are injurious to the health of both vegetables and animals; they retard the operations of the plough, and they are obstacles to the adoption of a more perfect system of drainage. There are, moreover, other attendant and considerable disadvantages from the small-field system. They require, for instance, more gates to be kept up and renewed; they increase the number of small lanes, or cart tracks, leading from one part of the farm to the other; they require more time and labour in their tillage.

The damage, remarks Mr. Grant, from shade, is the greatest in those hedges which run east and west. So that to do the least damage, and to be of the greatest service as shelter, (our most prevalent winds being from the west and south-west,) hedges should be made, and the long way of the fields be, from north to south. Again, the injury done to the field by the roots of trees in small inclosures is far more considerable than is commonly understood. "In any parish," adds Mr. Grant, "this evil is felt, but in such a parish as that of Rewe, in Devonshire, where there is much timber, one may see when the ground is laid open by the plough that the roots of the trees *cross each other from opposite sides of the field.*"

And if we find these superabounding hedges in the West of England, to an equally injurious extent are they suffered to exist in many of the districts of the eastern portions of the kingdom. To these Mr. J. Grigor earnestly alluded in his prize essay on fences, (*Jour. Royal Agric. Soc.* vol. vi. p. 194,) and his observations are entitled to the greater weight, since he is evidently reluctantly pleading (as we all must who are sensible of the picturesque beauties of hedgerows) against them. He says, truly enough, that they abound with "traits of beauty in the varied outline they present, filled as they are with so many of our sweetest flowers and shrubs." But the same remark is applicable to all districts in a state of nature. Thus, there are interminable wastes of purple heath in abundance, which yield nothing to the community, and are enjoyed only by a few, as a scene of solitary beauty, once in a season. To uphold such scenes, as well as our picturesque hedgesides, seems to be the work only of poets, whilst a growing population views such matters through a pressing necessity, and desires the bread-yielding plants instead.

The mode adopted by Mr. Grigor to ascertain the extent of the hedge incumbrances on some of the Norfolk parishes, was by measuring a square mile of each (640 acres). He found that in one of these parishes, that of Lakenham, the trees and hedgerow timber occupied more than 66 acres, or 10½ per cent. of the land. In Bixley, Arminghall, and the adjoining parishes, they occupy 6⅓ per cent., in Dereham 12¼ per cent., and in Hethersett 12¾ per cent. of the land. He calculates that 43,000 acres of land are occupied by the hedgerows of Norfolk only. Such is the evidence afforded by an inhabitant of East Norfolk. The testimony given by a farmer of West Norfolk is equally decisive. Mr. W. Cambridge (*ibid.* p. 335) contends against the use of hedge ditches in dry and well-drained lands. He says, very truly, that ditches, when made

on high land, very generally remain dry, and are in all cases admirably adapted for raising docks, and all kind of weeds, the seeds of which, when the ditches are scoured, and the scourings used, as they usually are, for the bottom of dung-heaps, are unwittingly carried and spread on the land.

In the south of England, the overcrowding of hedges and hedgerow timber is well described by Mr. J. H. Turner, of Wythyam, in Sussex (*ibid.* p. 479). He calculates the loss in the ploughing of 100 acres divided into small inclosures, instead of fields of 10 acres, to be equal to the amount of two days' work. In Sussex, so injurious have the roots of the hedgerow trees been found in some of the hop grounds of that county, that the farmers have a practice of digging trenches six or seven feet from the stem of the tree, so as to thus divide and separate from the surrounding crop the roots from the trees in that direction.

Mr. Hewitt Davis, when describing the improvements effected on the Spring Park Estate in Surrey, says, (*ibid.* vol. v. p. 527,) "My land, at the time I took it, was much subdivided by ditches and borders, and shadowed by scattered trees. The evil from this, I soon saw, was very considerable; much loss of time in tillage occurred by the frequent turns thus occasioned, and I had early learned that time was money; the weeds from the borders were continually spreading out into the fields, and the trees threw an injurious shade, and besides robbing the land were highly mischievous, and occasioned considerable loss. To remedy all this, I proceeded forthwith to fill in the ditches and grub the borders, taking care, when necessary, to first lay in the ditches capacious drains. In this way I must have largely added to the average yield of my land, without bringing *any addition to my rent, or parish rates, and with positive reduction*, in all the expenses of cultivation;" and he remarks in another work, (*Farmer's Almanack*, vol. iii. p. 39,) "Were no other injury done to the crops by trees and hedges in small inclosures than that which arises from their mischievous shade and shelter, it would be equivalent to the ordinary rent of such fields; but the farmers sustain a further loss in the additional time occupied in its tillage by the more frequent stoppages and turns they cause, and by the encouragement to idleness in the men that their cover affords. I believe arable fields, with large hedges and hedgerow timber round them, whose dimensions are under eight acres, are seldom or never worth a farmer's cultivation. I see much poor open down land in profitable cultivation, and large districts of inclosed land, of far better quality, ruinous to the occupiers; and I have not a doubt that to the difference in the size of the fields this may be often principally if not entirely traced. (See "*Fences*," in *British Husbandry*, vol. ii. p. 534.)

The loss to the *landlord*, by growing hedgerow timber, has been thus calculated by Mr. Knight, (*Ag. Gaz.* vol. ii. p. 374,) for 100 acres of land, divided into inclosures of five or ten acres:—"Suppose that 200 trees are growing upon it, that they would be worth at the end of fifty years 30*s.* each, they would realise the sum of 300*l.* Now, supposing the trees were removed, the tenant would gladly pay a shilling an acre more, and this would answer the purpose of the landlord very well; for, in the course of fifty years, this additional rent, put out to compound interest, at 3 per cent., would realise 560*l.*; and if you allow more trees to exist, the calculation is still the same in its results, for the farmer would then pay more to be rid of the incumbrance of hedgerow timber. And as my friend Anderson, of Oakley, said, at a discussion on this subject at the Farmers' Club House, in

London, after denouncing the growth of hedgerow timber as the greatest curse which could be inflicted upon the tenant, 'in thus speaking up for the tenant, we are doing the greatest service to the cause of the landlord.'"

Let the landlord and the tenant carefully consider these things; let them examine with care, and let them adopt cautiously the conclusion to which the evidence of their senses leads them, in this most important question; but, having once been convinced of the wisdom of an alteration, let them proceed with their wonted energy and promptitude to abate the hedgerow nuisance wherever it exists. But, in doing so, let them not fancy that the removal of hedges and hedgerow timber is needed, or even desirable, on all soils and in every district, for such sweeping general conclusions are ever the bane of agricultural improvement. On the contrary, there are many grazing districts and grass lands where moderate-sized inclosures and well-timbered hedgerows are exceedingly beneficial, and on all soils a certain degree of shelter is needful; but, after making these and other reasonable deductions from the promised benefits of hedgerow removals, they may still safely conclude with the Farmers' Club of London, "that upon the whole the growth of hedgerow timber is in general highly injurious to the interests of both the landlord and tenant, as well as to the country at large."

SECTION V.

THE IMPROVEMENT OF THE SOIL.

LAND DRAINING *.

It was an early and just observation of those great improvers of agriculture who followed in the train of Walter Blyth and of Jethro Tull, that the removal of land water is the foundation of all good farming. It is true that the axiom is admitted pretty universally, that it is an operation now carried on with almost annually increased perfection and profit to the farmer, and it would perhaps be still more systematically and advantageously extended if the occupier and the young cultivator more clearly understood the ill effects which land water produces, even at considerable depths, on the crops which grow over it.

The question, as I have in another place remarked, (*Bell's Messenger*, No. 2,645,) sometimes occurs to the young farmer, "What difference is there between rain water and that which was once rain water too, that of the land? Why should we covet an abundant supply of the first, and be anxious for the removal of the last? Is there any difference in their composition?" This difficulty the chemists of our time have very readily answered. They have shown, amongst other causes of difference in their value, that rain water contains ammonia, of which land water is commonly destitute. This presence of ammonia in rain water has been placed, as Liebig remarks, beyond all doubt; it may also be detected in snow water, and it is worthy of observation, that the ammonia obtained by the chemical philosopher from these sources possesses an offensive smell of perspiration and animal excrements, a fact which leaves no doubt respecting its origin. And again, Hunefeld, and other German chemists, have proved the existence of carbonate and nitrate of ammonia in the waters of many springs; in minute quantities it is most probably to be found in that of most springs, and this may

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* *Supplementary Note, No. 7. See "British Husbandry," vol.* i. *p.* 447–62.

tend to account for one of the observations of the skilful owners of the water meads of the great English chalk formation. They have remarked, that the water of this stratum, as it issues, cold and bright as crystal, from the ground, is much better adapted for their purpose than when, in its course toward the sea, it has gradually acquired an increase of temperature and a portion of finely divided and other organic matters. They remark, too, that if this spring water is thus employed for the purpose of irrigation, that after it has passed over one meadow, it is almost useless to employ it a second time for a similar purpose. "Something is taken out of it by the first grass," once remarked to me an excellent owner of one of these great water meadows, "which the second meadow cannot find in it." The same able farmer, who had noted these things in the case of the chalk springs of the upper portion of the Valley of the Itchen, had also remarked that the copious waters of that river, although deteriorated for the purposes of irrigation by their employment in the meads *above* the city of Winchester, were nearly as valuable as ever after they had passed that city, and been mixed with the contents of its sewers. (For an analysis of sewer water see *afterwards* under Manures.)

It is to the presence of ammonia, then, in such waters, that one source of this effect may be attributed. It is true that the ammonia contained in rain water is in very minute proportions, and in spring water the proportion is probably still less; but then it must be remembered, what is not commonly very clearly understood, that the weight of water which annually falls upon the farmer's fields is very great. "If," remarks Liebig, (*Organic Chem.* p. 75,) "a pound of rain water contains only one-fourth of a grain of ammonia, then a field of 40,000 square feet must receive annually upwards of 80 lbs. of ammonia or 65 lbs. of nitrogen (ammonia is composed of nitrogen and hydrogen); for, by the observations of Schubler, (made in Germany,) about 700,000 lbs. of rain fall over this surface in four months, and consequently the annual fall must be 2,500 lbs. This is much more nitrogen than is contained in the form of vegetable albumen and gluten, in 2,650 lbs. of wood, 2,800 lbs. of hay, or 20 tons of beet-root, which are the yearly produce of such a field; but it is less than the straw, roots, and grain of corn which might grow on the same surface would contain." The proportion of rain water which falls annually in Hertfordshire, upon an acre of ground, has been given by Mr. Parkes (*Jour. R. A. S.* vol. v. p. 151) in tons. Of this a very considerable portion sinks into the earth or is carried off by the drains, the other portion is removed by insensible evaporation. By the following table the farmer will see how much the relative evaporation and filtration of the rain water varies at different seasons of the year, and, as might be reasonably concluded, how greatly its annual amount also varies:—

	April to Sept. incl.		Oct. to March incl.	
	Filt.	Evap.	Filt.	Evap.
1836 ...	212	1023 ...	1574	330
1837 ...	10	982 ...	693	452
1838 ...	12	1082 ...	855	393
1839 ...	263	1500 ...	1246	159
1840 ...	—	980 ...	829	362
1841 ...	—	1544 ...	1437	269
1842 ...	131	1099 ...	1059	387
1843 ...	100	1822 ...	720	538
Mean	91	1192 ...	1052	360

Then again it has been shown that the oxides of iron and alumina (clay) all possess the power of absorbing, and of uniting with ammonia of the atmosphere, and it is upon this principle that one great advantage of applying burnt clay to certain soils may be ascribed; and, as Liebig in another place remarks, (*Organic Chemistry*, p. 90,) " the ammonia thus absorbed by the clay or ferruginous oxides is separated by every shower of rain and conveyed in solution to the soil." Of the use of this alkali to the farmer's crops there is no doubt, for, as the same great chemist adds, " no conclusion can have a better foundation than this, that it is the ammonia of the atmosphere which furnishes nitrogen to plants." The way, too, in which ammonia is formed in the soil, by the decomposition of its organic matters, affords us one easily understood reason for the advantages derived by the removal of its land water, a process which is thus clearly explained by Professor Johnston (*Elem. Chem.* p. 22): " Ammonia is naturally formed during the decay of vegetable substances in the soil. This happens, either as in animal bodies, by the direct union of their nitrogen with a portion of the hydrogen of which they consist, or by the combination of a portion of their hydrogen with the nitrogen of the air; or when they decompose in contact with air and water at the same time, by their taking the oxygen of a quantity of the water, and disposing of its hydrogen at the moment of liberation, to combine with the nitrogen of the air, and form ammonia. In the two latter modes, ammonia is formed most abundantly when the oxygen of the air does not gain the readiest access. Hence, in open subsoils, in which vegetable matter abounds, it is most likely to be produced; and thus one of the benefits which arise from thorough draining and subsoil ploughing is, that the roots penetrate and fill the subsoil with vegetable matter, which, by its decay in the confined atmosphere of the subsoil, gives rise to this production of ammonia."

It is evident, then, that if the surface or subsoil is already surcharged with stagnant land water the entrance into it of the rain water, which is so beneficial to the crop by the presence of ammonia and the atmospheric gases, and also by promoting the decomposition of the materials of which the soil is composed, is entirely prevented; and, moreover, by this occupation of the soil by land water, another ill effect upon the soil is produced, its temperature is reduced. " The presence of too much water in the soil," says Professor Johnston, (*Chem.* p. 109,) " keeps it constantly cold. The heat of the sun's rays, which is intended by nature to warm the land, is expended in evaporating the water from its surface; and thus the plants never experience that genial warmth about their roots which so much favours their rapid growth." It is true that the temperature of the surface soil commonly decreases as it recedes from the surface. In the experiments of Tubingen, (*Jour. R. A. S.* vol. v. p. 138,) the temperature of the sun in the shade being 59·7, that of the soil in the sun was—

On the surface	86·7
At three inches below	69·8
At four feet below	59·7

It is true, I repeat, that the thermometer descends the deeper we place it in the soil, but then it is equally true, (and the fact is another illustration of the beneficial results of deep drainage and deep ploughings,) that the temperature below the surface is the more considerable in the best stirred and well drained soils. In some experiments of Mr. Parkes (*ibid.* p. 141) made on Chat Moss, in Lancashire, during June 1837, he ascertained that, although the constant temperature of the *natural* bog,

surcharged with water from 12 inches to 30 feet, was 46°, and the thermometer planted in the same substance at 7 inches deep constantly indicated 47°, yet that in a portion of the same bog, well drained and deeply *stirred*, at a depth of 31 inches, it indicated a maximum temperature of 48½°, having gradually gained 2¼°, and being apparently (adds Mr. Parkes) still rising; and that in such well-prepared soils the action of the atmosphere is much more considerable and rapid than is commonly believed, is shown by the observation made during the same valuable experiments, that although the temperature of the natural unstirred soil at a depth of 7 inches was only 46°, yet that the mean temperature during 36 observations of the *stirred* and *drained* soil was 10° higher, and that after a thunder-storm it rose to 66°. The following is the result of their observations:—

	Temp. of atm. in the shade.	Time of observation.	Depth below the surface in inches.				
			31	25	19	13	7
June 10	70°	9 A.M.	46·1		48·2	50	53
15	60·4	9 A.M.	47·25	48·6	50·8	53	57·6
17	67	9 A.M.	48	50	52·8	55·6	58

We have here, as Mr. Parkes observes, satisfactory evidence that the occasion of heat was solely derived from meteorological agency, that is, from action on the surface, and not from the substratum, as the latter possesses invariably a lower temperature, which must have tended to diminish, rather than to increase, the heat finally acquired by the worked bed. And we may safely deduce from these facts that the origin of the increased temperature is attributable to the change induced on the mechanical condition of the soil by drainage and pulverization, as no other changes were effected in it in these experiments than those of comminution of its texture and the withdrawal of free water; we may safely conclude too, with Mr. Parkes, even from his experiments, that in the month of June rain water carries down heat and raises the temperature of the subsoil, whilst the loss of heat by the strata nearer the surface is quickly restored by the sun's rays. And another important effect is also observable in all soils properly prepared to receive heat and water, and permit their descent, viz., that the transmission of accessions of heat downwards continues during the afternoon of the day and throughout the night, whilst the superstrata (but chiefly from seven inches upwards) are losing some amount of their heat by conduction upwards and radiation. Such is the influence of good and deep drainage and ploughing upon the *temperature* of the soils thus improved. But the benefit does not terminate there; others follow from those operations, advantages which are thus well described by Professor Johnston (*Chem.* 110): " Vegetable matter becomes of double value in a soil thus dried and filled with atmospheric air. When soaked in water, their vegetable matter either decomposes very slowly or produces acid compounds, more or less unwholesome to the plant, and even exerts injurious chemical re-actions upon the earthy and saline constituents of the soil. In the presence of air, on the contrary, this vegetable compound decomposes rapidly, produces carbonic acid gas in large quantity, as well as other compounds on which the plant can live, and even renders the inorganic constituents of the soil more fitted to enter the roots, and thus to supply more rapidly what the several parts of the plant require.

It is to such labours as these that the farmer's gratitude is justly due: their value can hardly be too highly rated, and in the result no mean harvest has been produced; for there is no branch of agriculture that has attracted more general and successful attention within the last few years than the improved drainage of the land. Science has here gone successfully hand in hand with practice, to a very useful and very profitable extent. But, as Mr. Pusey truly remarks, (*Jour. R.A.S.* vol. iii. p. 169,) " the extension of science may mean, however, two different things, either the spread of existing knowledge amongst a wider number of persons—and this is a most important object; for if the best practice of each different district could become general in the country, a very great improvement in farming would at once be effected: or it may mean the discovery of principles hitherto entirely unknown." These remarks well apply to the subject of drainage. " It was only in 1835," continues Mr. Pusey, " that we heard in England, chiefly through Mr. Shaw Lefevre, the present Speaker of the House of Commons, that a manufacturer in Scotland, now well known as Mr. Smith of Deanston, had found the means of making all land, however wet and poor it might be, warm, sound, and fertile, and that this change was brought about by two processes, thorough draining and subsoil ploughing. His rule of draining was this, that we are not to endeavour merely to find out hidden springs, and to cut them through by a single drain, which in some of our books appeared to be regarded as all that was necessary, but that as the whole surface of retentive soils is rendered wet, not by accidental springs, but by the rain, the whole surface of the field must be made thoroughly dry by under-drains running throughout at equal distances. Any field," he said, " however wet, might be so dried, provided these under-drains were cut sufficiently near to each other." This was the principle of thorough or frequent draining asserted by Mr. Smith of Deanston, in 1835; and this principle, which was then new and startling to the generality of farmers, may now be regarded as firmly established. "But though it was then novel, I have discovered accidentally," continues Mr. Pusey, " that it has been long practised to its fullest extent in one part of England. In conversing with an old Suffolk drillman, he observed, ' that if he were the tenant of a strong clay farm, he should drain the whole of it with drains cut 12 feet apart, and 3 feet deep, and that that was the method he had seen when a boy at his native place.' Upon inquiry, I found that forty years ago three properties, one of them Lord Huntingfield's, near Yoxford, were drained in this manner, and I have reason to believe that the same effectual mode of draining has as long been practised in Essex, so much so as to be called the Essex system in Scotland; and this fact is by no means a singular proof how little the farmers in one part of England knew, until lately, what the others were doing."

That agricultural knowledge is indeed but slowly diffused, is shown by the fact that we are only now working out the true principles which a century since Jethro Tull so clearly and so ardently advocated; and even two centuries since, " honest Captain Walter Blythe," as Dr. Beale calls him, who was an officer in Oliver Cromwell's army, in a work published by him in 1649, entitled " The English Improver improved," ably advocated those chief principles of drainage which we are now only carrying into general effect. " Blythe dedicated his book," observes Mr. Parkes, (*Jour. R.A.S.* vol. vii. p. 252,) " to ' The Right Honourable the Lord General Cromwell, and the Right Honourable the Lord President, and the rest of that Most Honourable Society of the Council

of State.' In his instructions for forming the flooding and draining trenches of water meadows, the author says of the latter, 'And for thy drayning trench, it must be made so deep that it goe to the bottom of the cold spewing moyst water, that feeds the flagg and the rush; for the widenesse of it, use thine own liberty, but be sure to make it so wide as thou mayest goe to the bottom of it, which must be so low as any moysture lyeth, which moysture usually lyeth under the over and second swarth of the earth, in some gravel or sand, or else, where some greater stones are mixt with clay, under which thou must go half one spade's graft deep at least. Yea, suppose this corruption that feeds and nourisheth the rush or flagg should lie a yard or four foot deepe, to the bottom of it thou must goe, if ever thou wilt drain it to purpose, or make the utmost advantage of either floating or drayning, without which thy water cannot have its kindly operation; for though the water fatten naturally, yet still this coldnesse and moisture lies gnawing within, and not being taken clean away, it eates out what the water fattens; and so the goodness of the water is, as it were, riddled, screened, and strained out into the land, leaving the richnesse and the leannesse sliding away from it.' In another place he replies to the objectors of floating that it will breed the rush, the flagg, and the mareblab:—'Only make thy drayning trenches deep enough, and not too far off thy floating course, and I'le warrant it they drain away that under moysture, fylth, and venom, as aforesaid, that maintains them, and then believe me, or deny scripture, which I hope thou darest not, as Bildad said unto Job, 'Can the rush grow without mire, or the flagg without water?' (Job viii. 12.) That interrogation plainly shewes that the rush cannot grow, the water been taken from the root; for it is not the moystnesse upon the surface of the land, for then every shower should increase the rush, but it is that which lyeth at the root, which, drained away at the bottom, leaves it naked and barren of relief.'"

That even bricks were long since employed in Scotland, in the construction of drains, is shown by Mr. George Guthrie, of Culhorn, in Wigtonshire, (*Trans. High. Soc.* vol. viii. p. 45,) who discovered in a field at that place a number of brick drains, made more than a century since by the celebrated Marshal Stair, the hero of Dettingen; (they had a passage way of about four inches in diameter;) "one of them," he says, "appeared to be cut very judiciously where the open stratum approached to the clay, or between the 'wet and dry' as drainers would say, about thirty-one inches deep, and catching a good deal of the water. The state of these drains," remarks Mr. Guthrie, (and the account of these is useful as an instance of the probable general extent of the *durability* of brick or tile drains,) "has left the conviction on my mind, that tile drains, if properly executed and attended to, may last for many generations, and that there is no ground for the dread entertained by many that the small opening of the tile will soon sludge up."

The efforts of Mr. Smith, and others, speedily led to very valuable improvements in the construction of draining tiles, machines for the manufacture of which were speedily produced by the Marquis of Tweeddale, Mr. Beart, and others. This machine was thus described by Mr. James Hunt (*Jour. R. A. S.* vol. ii. p. 148).

The machine invented by the Marquis of Tweeddale is on the simplest construction, and may be described as follows:—A trough is made at the head of the machinery, of the exact width of the intended tile. Into this the clay is placed by a workman, and is drawn through two revolv-

ing cylinders, compressing it with great force, so as to give it a consistency and firmness unattainable by hand labour.

The clay thus flattened by the rollers is drawn forward by the machinery on a web of canvass, and passed through moulds which give it the exact shape which it may be required to bear, when it is cut off, by a very simple process, at any length which the maker may desire: thus, every tile being pressed in precisely the same manner, passed through the same moulds, and cut off at exactly the same length, they all obtain a uniformity of size and construction which is not to be attained to a similar extent by any other manner.

The tile, being thus made, is carried away by an endless web passing over rollers which are turned by the same machinery that makes the tile, and thus travel of their own accord, without the labour of carriage, between the sheds erected for their reception, in which they are placed in rows on either side by labourers stationed for the purpose.

By these means four or five men can in a day make with ease from 8,000 to 10,000 tiles, all of uniform shape, size, and consistency, which, when formed of good clay and properly burnt, attain almost the durability and firmness of stone. It may indeed be safely affirmed of them, that if properly planted in the soil they would last almost for ever.

Mr. Beart, of Godmanchester, after describing his machine (*ibid.* p. 100) continues:—

"I would observe that the clay best adapted for tiles is that which contains a small proportion of sand or marl, or sand may be mixed with the clay when raised in the winter. Clay thus mixed does not contract so much in drying, and the tiles, when burnt, are larger and sounder; but, as tiles must be made from clay beds in the locality where they are required for use, it will be expedient to consult practical men acquainted with the soil.

"As regards furrow draining on tenacious clay soils; the drainage of these soils has generally been done in shallow depths, under the prevailing common opinion that otherwise the water would not get into the drains. The *contraction* which beds of clay undergo when cut through by parallel drains has thus been entirely overlooked. This contraction, however, is most important, so much so (as I have found by experience) that drains dug from 30 to 40 inches deep have operated to much greater advantage than those of shallower depth. The bed of clay contracts itself near the drains as deep as the drains are made; and the deeper the bed of clay is contracted, the larger will be the fissures for the water to percolate through to the drains. In well-drained land, the water does not enter the drain by the furrow, but percolates through the fissures (formed by contraction) from the ridge to the drains. It is also, I consider, an error to cover tiles with loamy soil or vegetable substances; these have a tendency, after a few years, to choke the drains: the best covering upon them is the clay itself. The action of the atmosphere will always so contract the clay that there will be sufficient fissures for carrying the water into the drains. This is proved by the system of block-draining, which is sometimes performed on very strong clays in this county. The plan is to dig out the drain, lay a block of wood in the bottom of the drain, then beat the clay firmly upon the block, and after drawing forward the block the same operation is repeated. Now there is no complaint that the water does not enter these drains, for the contraction of the clay which always takes place remedies the supposed obstruction."

The kind of clays best adapted for drain-tile making are thus

described by Mr. Etheredge, in a very useful article upon the cheapest and best method of establishing a tile yard (*ibid.* vol. vi. p. 463).

"All laminated, plastic, and potter's clays, and those free from stones and other impurities, such as are found on the banks of the Tyne; in Flintshire; on the Clee Hills, and at Madely in Shropshire; about Wareham and Poole, in Dorsetshire; in the New Forest in Hampshire; on the banks of the Medway in Kent; and in various other places; may be ranked among the best for drain-tile making. Little difficulty is found in their preparation, as they merely require to be dug in the winter, and thrown up on beds, when they are fit for the pug-mill in the spring.

"A peculiar clay occurs near Hexham in Northumberland, almost like a quicksand in nature. It requires no working or winter's frost to improve it, but may at once be dug from the ground, pugged, and moulded, either by machinery or hand, into pipes or tiles of excellent quality. To this may be added all clays lying under peat-bogs, such as are found in South Wales and in various other districts.

"Clays, less tenacious and full of small lumps, provincially termed nubs (not stony), should, early in the winter, be turned up in beds, not exceeding in thickness from 2 to 2½ feet, to receive the frost, which seldom penetrates to a greater depth. The clay thus wintered will be fit for use in the spring and summer following. These are found near the Dover railway below Tunbridge, in Kent; in Hertfordshire, and elsewhere.

"Clays not adhesive, but which become so by working, are found in Northumberland, Warwickshire, Worcestershire, Herefordshire, Derbyshire, Nottinghamshire, Leicestershire, and near Preston in Lancashire. They are generally of a red colour, and marly, full of very small stones, sometimes limewash, provincially termed *race*, and lie in beds of from 3 to 20 feet deep. They require to be dug in the early winter months, and I recommend crushing rollers to be used for the purpose of equalizing their texture, breaking the stones, and dissevering the race."

In 1843 the English Agricultural Society awarded a prize to Mr. Thomas Arkel, for his valuable practical Essay on the Drainage of Land (*Journal*, vol. iv. p. 318). And in the same year Mr. Josiah Parkes made a very useful Report to the Society, on Drain Tiles and Drainage (*ibid.* p. 369). In this he gave the following tabular view of the expense, size, &c., of the draining tiles as produced by the machine of three different makers:—

Kind of Tile.	Internal Dimensions.	Weight per thousand.	Length.	Weight per 1000 feet.	Lineal feet per ton.	Thickn. of Material.	Price per thousand.		
	In. In.	lbs.	In.	lbs.	Ft.	In.	£	s.	d.
Tweeddale .	2¾ by 2¾	5500 tiles and soles.	14	4631	464	0·55	2	2	0
Etheredge .	2½ — 1½	5376 „ „	14	4527	495	0·65			
„	2½ — 1½	5600 „ and covers.	14¼	4717	475	0·65	1	10	0
„	1½ — 1½	5152 „ „	14¼	4338	539	0·65			
„	1½ — 1½	4928 „ and soles.	14¼	4150	516	0·65			
Read, No. 1	2·25 diam.	2844 pipe.	12	2844	787	0·40	1	18	0
„ 2	2·00 „	2657 „	12	2657	843	0·40	1	14	0
„ 3	1·60 „	1937 „	12	1937	1156	0·35	1	9	0
„ 4	1·35 „	1313 „	12	1313	1706	0·35	1	5	0
„ 5	1·00 „	1032 „	12	1032	2170	0·25	1	1	0

Pipe-tile.—"It does not appear," observes Mr. Parkes, (*Jour. R. A. S.* vol. iv. p. 372,) "from the inquiries made on this subject, that pipes have

been anywhere used for land-drains at a period more remote than thirty-five years since, about which time Mr. John Read made and employed them when farm-servant to the late Rev. Dr. Marriott, of Horsemonden, in Kent*. These original pipes were about three inches diameter in the bore, and were formed by bending a sheet of clay, as usually prepared for the common drain-tile, over a wooden cylindric mandril. In consequence of the imperfect union of the two faces of the clay, a narrow slit was left throughout the length of the tile, which served, and was then thought necessary, to admit the water. They were found to act well, but their use did not extend so rapidly as it might otherwise have done had not Mr. Read quitted his farming employment to devote himself, in London, to the manufacture of his celebrated stomach-pump, and other surgical and veterinary instruments." The preparation of a perfect cylindric tile, as now made by machine, seems to have originated in Essex, whence it travelled into Suffolk and Sussex. There were some made with sockets; first, I believe, by my friend Henry Dixon, at Rivenhall, in Essex: he thus describes his socket drain pipe (*ibid.* vol. v. p. 603).

"They are applicable particularly to loose springy soils, and cannot fail to be safe. Some persons prefer holes to be made in pipes; but they appear to me to be in all cases unnecessary. These pipes may be made of any length; the most convenient and useful is probably from 15 to 18 inches; and the cost of the socketing by the machine (I use Ford's patent) is from 2*s.* 6*d.* to 3*s.* 6*d.* per thousand. I have inclosed with the pipes a curious evidence of the facility with which the roots of trees will destroy drains, if carelessly placed. The mass of fibres are the roots of a willow-tree, growing about five or six feet from the drain, which had been put down only twelve months, and the pipe from which I took it was a four-inch socketed one.

"I am sorry that thin one-inch pipes find advocates; they have no recommendation but cheapness, and must fail. In my judgment, as well as in that of many experienced drainers here, no pipe should have a less bore than two inches in the clear; and in many cases, even for surface-draining, it should be larger; and it should possess substantial thickness, to give it durability.

"On Wednesday last, so soon as the heavy rain of that day ceased, I examined the outlets of a field of 18 acres of young clover, which was surface-drained, five years ago, 24 inches deep and 21 feet apart. The outlet, or discharging conduits, were fifteen in number, so that each had to carry the water from but little more than an acre of land; and yet the water from each of those outlets would have filled at least three one-inch pipes; and if such small pipes had been used, every drain would have been blown. Upon fallow-land of the same description the water would have been discharged in even a larger volume."

The arguments which have taken place, and the discordant nature of the evidence which has been produced with regard to the use of small one-inch pipes, may perhaps be attributed to the difference of the soil on which they have been employed, and the length of the drains. Mr. Parkes, in speaking of these, remarks, (*Jour. Roy. Agric. Soc.* vol. vi. p. 127,) "I refer to pipes of an inch bore, a size sufficiently large for

* Pipes were, however, used for drainage 40 years since, in the park of Sir Thomas Whichcote in Lincolnshire. Mr. Robert Harvey, of Epping, patented a machine in 1817, for making tiles by vertical pressure; they were also used in 1826, at Tew, in Oxfordshire, for a similar purpose. (*Jour. R. A. S.* vol. vii. p. 692.)

all the parallel or general drains in most descriptions of land from which surface-water alone, that is, rain-water falling on it, has to be removed. In cases where land is wetted by springs, the bore of the pipes used must necessarily be larger, and adapted to the quantity of water to be conveyed away in each particular case. This will augment the cost of drainage in soils of certain texture, though not in all; as it may happen, and I have met with many such instances, that a single spring, though small in itself, has saturated a whole field; and a single drain, placed at sufficient depth, has laid the whole of that field dry.

"There is another condition of things which materially affects the cost of drainage, viz., the size of the fields, and the nature of the boundary fences and outfalls. I am at present about to execute the drainage of two estates, in one of which each field, ranging in size from about 10 to 25 acres, has a deep ditch or a running stream at the foot of every slope, so that not a single carrier or main drain will have to be laid down. Few other than inch-bore pipes will there be requisite. In the other estate there are but few ready-made ditches, so that covered carrier-drains, proportionate in size to the number of the parallel drains emptying into them, and to the distance of the outfall, will have to be constructed. All other circumstances, therefore, being alike, the drainage of the latter estate will be the more costly*.

"These different circumstances, the ever-varying character of soil as respects its power of transmitting water, which must govern the judicious drainer in his choice of depth and distance, with other conditions, such as the relative hardness of the subsoils to be excavated, necessarily render it impossible to assign one cost as an universal rule in drainage. The instances of cost given in the table comprehend a variety of soils and subsoils, the texture of which occasioned very different wages to be given for opening out the trenches. The pickaxe had to be resorted to in Nos. 6, 7, 9, whereas Nos. 1, 2, 3, 4, 5, exhibit the usual charge in the district for excavating uniform, or, as you well call them, *honest* clays at the depths cited.

"I have preferred to quote instances of drainage as effected by tenant-farmers rather than work executed under my own direction, in the belief that more satisfactory evidence of cost will be thereby afforded to the agriculturist; and because it shows that what one man has done, another may do, and that without having recourse to professional drainers. The drainage performed by the tenant-farmers whose names and addresses are given, cannot, as far as I am aware, be improved upon, except that those who have drained at three feet deep, would now be urged, by their experience, to lay their pipes at four feet deep, in preference, wherever practicable."

* The drift stoppage matters of drains is sometimes a source of great annoyance to the farmer, especially on soils abounding with ferruginous matter. A deposit of this kind from Sir R. Peel's, at Drayton Manor, was found by Mr. R. Phillips to contain (*Farmer's Almanack* iii. p. 50)—

Silica and alumina	49·2
Peroxide of iron	27·8
Organic matter	23

INSTANCES of the Cost of Draining an Acre of Land, the Drains being laid with Inch Pipes at various depths and distances asunder; the Pipes being assumed to cost Six Shillings per Thousand if manufactured upon an Estate.

Depth of Drains.	Distance between Drains.	Length of Drain per Acre.		Cost of digging Drains.		Pipes per Acre.	Cost of Pipes per Acre.	Total Cost of Drains per Acre.	Character of Soil.	Authority and Place.
Feet.	Feet.	Rods.	Furlongs.	Per Rod.	Per Acre.	Feet.	s. d.	£ s. d.		
3	33	80	2	3d.	20s. 0d.	1320	7 11	1 7 11	Uniform clay.	Thomas Hammond, tenant-farmer, near Penshurst, Kent.
3	33	80	2	3	20 0	1320	7 11	1 7 11	Ditto	Henry Putland, tenant-farmer, Saylherst, Sussex.
3 to 4	33	80	2	4	26 8	1320	7 11	1 14 7	Ditto	John Thompson, tenant-farmer, Woolver's farm, Horley, Surrey.
3 ft. 6 in. to 4	40	66	1·65	4	22 0	1089	6 6	1 8 6	Ditto	Thos. Hammond.
4	50	53	1·325	6	26 6	875	5 3	1 11 9	Clay, with some stones.	Ditto.
3 to 3 ft. 6 in.	49½	53·3	1·333	8	35 6	880	5 4	2 0 10	Clay, super; hard gravelly subsoil.	Henry Simmonds, tenant-farmer, Hadlow, Kent.
4	49½	53·3	1·333	8	35 6	880	5 4	2 0 10	Clay, super; hard gravel bottom.	—— Kepping, Hadlow, Kent.
4	66	40	1	8	26 8	660	4 0	1 10 8	Various; clay, gravel, sandy loam.	Ditto.
3 ft. 6 in. to 4	33	80	2	7½	50 0	1320	7 11	2 17 11	Clay, super; hard black gravel, and springy subsoil.	Jno. Taylor, tenant-farmer, Mereworth, Kent.
2 ft. 6 in. to 3	30	88	2·2	Stone Drains; cost 14¾d. per rod for digging, getting, drawing, and breaking the stone, and filling in.				5 8 2	Clay and stiff loam, super; with stones in subsoil.	—— Bartlett, tenant-farmer, Butleigh, Somerset.
3	20	132	3·3	Ditto.				8 2 3	Clay, with some boulders in subsoil.	—— Maidment, tenant-farmer, near Butleigh, Somerset.

To the history of the introduction of tiles and pipes in thorough draining, Mr. Parkes, in his lecture at Newcastle, in July 1846, referred when he remarked, (*Jour. R. A. S.* vol. vii. p. 251; *Farmers' Magazine*, vol. xxvi. p. 137,) "In the year 1843, at the Derby show, Mr. John Read exhibited a few specimens of pipes. This was followed by an investigation into the use and merits of pipes made, at the instance of the council, by myself in Kent, and reported in the second part of the Journal of the same year. There existed only, at that time, a machine of a rude kind for manufacturing drain-pipes; but through the widespread information conveyed by the pages of the Society's Journals, and the prizes offered by it for superior machines, we have arrived, in the short space of three years, to that agreeable dilemma which actually renders the selection in our show-yard of the most meritorious pipe machine a matter of no little difficulty. From a machine having the faculty of producing about 1,000 feet of pipes per diem, we have advanced, in less than three years, to the faculty of making 20,000 feet in the same time."

On the cost of tiles when ready for sale, Mr. Parkes remarks (*Jour. R. A. S.* vol. vi. p. 474):—"This is the most difficult question to answer, as no general rule can be laid down. I know a tile-yard in Norfolk where the clay is blue, full of chalk and stones, which is washed to free it from these impurities; the contract price is 9*s.* 6*d.* per 1000, including every expense; the tiles are 15 inches long, made with a flange: price of coals 24*s.* per ton. These tiles are sold at 16*s.* per

1000; and the soles, of the same length, at 10*s.* per 1000. These are made by Etheredge's machine." Mr. Parkes states that pipes made by Clayton's machines, of inch bore, are sold at Yarmouth, Isle of Wight, at 12*s.* per 1000, 12 inches long; pipes 2⅛ inches bore, at 18*s.* per 1000, 12 inches long; coals about 20*s.* per ton. Mr. Hodges states that pipes 1 inch bore, 12 inches long, made by Hatcher's machine at Benenden, Kent, are sold at 12*s.* per 1000; 2¼ inches bore, 12 inches long, at 20*s.* per 1000; coals at 24*s.* per ton.

The great difference in the price of tiles arises from good or bad management. I know two yards, one in Worcestershire, the other in Herefordshire, where there is a difference of 11*s.* per 1000 in the cost of producing the same sized tiles; coals the same price at both yards, and both using the same machine. If a machine of any kind will make cheap and good tiles at one tile-yard, it will at another. The great evil is, that the inventors of the machines do not make it imperative on purchasers to allow them to send a man to start them properly; for if the slightest difficulty is found by the workmen the machines are condemned (as they are generally prejudiced against improvements) with only a few hours' trial. (See *Brit. Husb.* vol. i. p. 458.)

Those who are proposing to pipe-drain running sands may consult with advantage Mr. William Linton's prize essay on this subject (*Jour. R. A. S.* vol. vii. p. 115). He observes, "of these running sands I have drained about 500 acres; and, when the plan which has been stated was adopted, the average cost per acre was about 5*l.* 5*s.*; that is to say, 1500 tiles, at 26*s.* per 1000; 8000 bottoms, at 11*s.* per 1000; cutting, 1*l.* 10*s.*; and incidental expenses, 3*s.*: total, 5*l.* 5*s.*" And he adds a remark which well applies to all tile draining: "All rapid falls are particularly avoided, or the drain will wash away in spite of all precaution, especially when a strong run of water occurs."

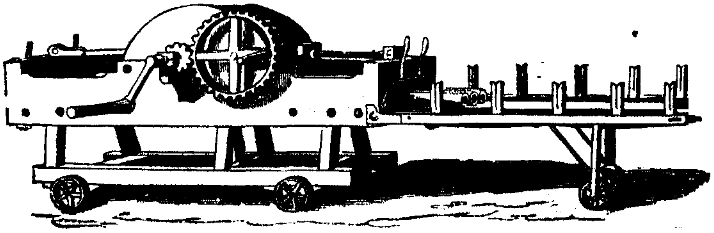
DRAIN TILE OR PIPE MACHINES.

I adopt most cordially the sentiments expressed in the report of the judges of the tile machines, exhibited at the Shrewsbury meeting, when they remark (*Jour. R. A. S.* vol. vi. p. 318):—The selection fell on machines respectively made and exhibited by Mr. Clayton, of London; Mr. Beart, of Godmanchester; and Mr. Scragg, of Calveley, Cheshire. The final trial of these was made at Pusey, and the Society's prize then adjudged to Mr. Scragg. There is so great an interest and importance attached at the present time to machinery for preparing the materials of drainage, that little less than a volume would suffice to satisfy the public appetite for knowledge on the subject. But neither treatise nor manual can make a pipe or tile manufacturer; nor can this report be extended beyond an explanation of the principal reasons which guided the judges, appointed by the Society, in the application of the prizes placed at their disposal, with the mention of such matter as may be incidental to the particular subject. Mr. Beart's machine was found to be inferior to both the others—first, in the faculty of freeing the clay from stones; secondly, in the quantity of work done in a given time.

Both Clayton and Scragg's are excellent machines, and they are both practically adapted for the service of the tile-yard. They are, however, constructed on entirely different plans. Mr. Clayton's is a perpendicular and fixed, Mr. Scragg's a horizontal and locomotive, machine. The judges preferred the latter principle, as more convenient, as economising labour, and as saving valuable space in the management of the goods in the drying shed. The method of cutting off the pipes or tiles

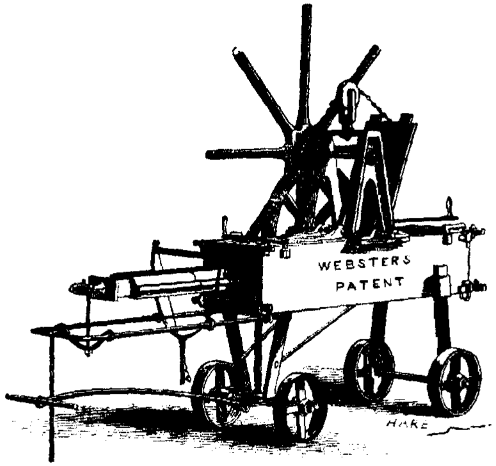
to determinate lengths is imperfect in Clayton's; it is mathematically correct in Scragg's machine; and this is a matter of no slight importance in stacking the pipes or tiles in the kiln. The screening or freeing the clay from stones, roots, or other extraneous matter, is performed with less labour by Mr. Scragg than by Mr. Clayton; but the judges think it possible that cases may occur in which Mr. Clayton's perforated screen may prove to be superior to Mr. Scragg's barred screen, as exhibited at Shrewsbury. The cost of Mr. Scragg's machine is considerably less than Mr. Clayton's, the dies included; and Mr. Scragg's dies are made on a principle which is considered to be far superior, in the important points of accuracy and simplicity, to those of any other maker of pipe machines. Finally, Mr. Scragg's machine was proved to produce a greater number of articles in a given time than Mr. Clayton's, and the latter than Mr. Beart's. The judges have thought it right to adduce the foregoing close contrast between the merits of Mr. Clayton's and Mr. Scragg's machines, because they considered both of them to possess qualifications of a high order, and far superior to those of any other machines exhibited; and because the reputation of Mr. Clayton's machine has been well merited, and notoriously well established. They do not think they would be doing their duty to the Society without reporting thus succinctly the motives of their judgment. Mr. Scragg's machine is equally well adapted to the manufacture of the horse-shoe tiles as of pipes, and of most other descriptions and forms of articles commonly manufactured in tileries or required in drainage. The writer has one of them in use, made since the show at Shrewsbury, which produces nearly double the quantity of the machine shown there. It is equivalent to the easy manufacture of more than 20,000 pipes, of an inch bore, per day of 10 hours, and so on in proportion for other sizes; it is also worked at a less cost of labour, and with greater ease to the workmen, than any other machine with which he is acquainted.

This machine is new to the Society, but not so in reality, as a model of it was shewn to the writer immediately after the Derby show, by Mr. Davenport, of Copesthorne, Cheshire, (Mr. Scragg's employer,) who also informed him that it was at work on his own premises, as then constructed, with two distinct dies for making horse-shoe tiles. This was set to work in August 1842, and was, as the writer thought till very recently, the earliest invented machine for producing more than one stream of ware of any kind at a time. It seems, however, that all these inventions—and particularly those for the manufacture of pipes—were long since anticipated by a machine in use at the pottery of Mr. John Watts, of Coleford, Gloucestershire. This gentleman informs the writer that his father purchased the machine forty-four years since; and at the Newcastle meeting the reporter added (*ibid.* vol. vii. p. 692) that he ex-



[*Scragg's Tile Machine.*]

pressed "his entire agreement in the bestowal of the prize of 20*l.* on the machine of Mr. Scragg, of Calveley, near Tarporley, whose machine also took the prize at Shrewsbury. It was considerably improved at Newcastle, and so were several of the competing machines; but no one of them would be found equal in practical use to that of Mr. Scragg."



[*Webster's Hand Pipe and Tile Draining Machine.*]

This valuable machine, the invention of Mr. W. B. Webster, of Hounsdown, and manufactured by Tasker and Fowle, of Andover, is thus described by those gentlemen. "It is made entirely of iron, weighs about 8 cwt., occupies a small space, is very simple, easily moved between the hakes, turned by a man or boy, and will make tiles or pipes of any shape, size, thickness, or length, of the most perfect description. It has two receptacles for clay. While the tiles are being forced out of one side, the other is filled, so that no time is lost, the piston acting both ways; and from its peculiar construction the confined air does not injure the tiles, therefore requires less care in filling. One or both sides may be used as a pug-mill, freeing the clay from all stones and roots, and in the winter season will be found serviceable for preparing clay, and other purposes, on a farm. By the simple cutting apparatus, each tile is made exactly the same length."

The cheapness and durability of tile and pipe drains has so very generally excluded the employment of all other descriptions, that it is almost needless to notice any modern attempts to improve the efficiency of the olden systems. On stone draining, and the implements used in effecting it, Mr. J. Robertson, Ladyrig, in Roxburghshire, has given an account (*Trans. High. Soc.* vol. viii. p. 36). He calculates the expense, with drains 33 inches deep, extending to 70 roods of 6 yards, to be, per acre, about 4*l.* 17*s.* 6*d.*; when the drains are 28 inches deep, 3*l.* 8*s.* 4*d.* per acre, the drains being 30 to 36 feet apart. Larch and Scotch fir pipes have also been employed in suitable localities; and it seems that these kind of pipes are much more durable than might be expected. Some of these, used at Netherby, in Cumberland some twenty-five years since, are, it seems, still running (*Trans. High. Soc.* vol. viii. p. 113). Mr. Scott, of Craigmoy, has advocated the employment of these tubes

been that the rural population had not observed the effects on their own health, but they had marked the effects of drainage on the health and improvement of animals. Thus the less frequent losses of stock from epidemics are beginning to be perceived as accompanying the benefits of drainage, in addition to those of increased vegetable production.

SECTION VI.

THE SAVING OF ANIMAL LABOUR*.

There is hardly a subject more interesting to the farmer than the economy of animal labour. It is a question which has, in the last few years, engaged the anxious study of the best friends of improved tillage, and of humanity to our beasts of burden; and, as I have already remarked, (*Bell's Messenger*, No. 2641,) an increasing attention to the saving of animal power is ever one certain result of advancing civilization. With such improvements the science of agriculture is intimately and closely connected. It is always refreshing to follow these quiet advances in the improved construction of labour-lessening implements, to note how steadily they have in a long course of ages progressed, and to usefully draw the attention of the stout adherent of the old rude implements of agriculture, and their still ruder harness, to the improved and still improving machines of the modern farmer. Time has, indeed, done wonders since the days of our Saxon forefathers, when each ploughman made his own plough and his own plough harness; and when, in still darker days, the more indolent and still more degraded farmers of Ireland were too lazy or too poor to make any plough harness whatever. It has sometimes been stoutly and reasonably denied that this was possible. Let, however, the reader refer to the act, still found on the statute-book of the now defunct Irish parliament, and he will find the barbarism recognised there, that they, instead of harness, actually employed the tails of their poor horses; and he will see that this custom certainly was formerly practised in Ireland to such an extent, that the legislature, in 1634, found it necessary to interfere, and by the 11 and 12 Car. II. c. 15, (Irish Parliament,) entitled, "An Act against plowing by the Tayle, and pulling the Wool off living Sheep," it was declared that "in many places of this kingdome there hath been a long time used a barbarous custome of ploughing, harrowing, drawing, and working with horses, mares, geldings, garrans, and colts, by the taile, whereby (besides the cruelty used to the beasts) the breed of horses is much impared in this kingdome. And also divers have and yet do use the like barbarous custome of pulling off the wool yearly from living sheep, instead of clipping or shearing of them." These wretched practices are then declared illegal, and to be punishable with fine and imprisonment.

THE PLOUGH.

As I had occasion to observe, in remarking in another place upon the great importance of researches which tend to the reduction of animal labour, the inquiry is in every point of view fraught with interest to the English farmer. Dwelling in a land of freedom, secure of receiving, under the blessing of Providence, the fruit of his labours, such an enlightened cultivator can with difficulty comprehend the reason for the

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* *Supplementary Note, No.* 8, "*Brit. Husb.*" *vol.* i. *pp.* 124, 168, 178.

still continued use in some countries of the rude implements of less instructed or of enslaved cultivators. My friend Mr. J. A. Ransome glances very truly at this state of things, in his valuable work on the implements of agriculture, when he is contrasting the beautiful and "labour-lessening" implements which the farmers of England and other free countries possess, with those of the cultivators of Spain, of Portugal, and of Oriental fields. The plough of these countries, if used at all in imperfectly disturbing the soil, is a rude, powerless implement, which at the best merely scratches the surface of the earth; and the rice cultivators, in preparing their swampy lands, sometimes escape the labour of ploughing entirely. They merely tread the water-covered soil to a sufficient degree of softness by the trampling of oxen or asses; and if their ploughs, or other expedients for disturbing the soil, are like those of uncivilized countries, rude, and worked with great unnecessary labour, their mode of covering the newly sown seed with earth betrays the same degree of infancy in the state of their agricultural mechanics. "The English farmer," remarks Mr. Ransome, "must not expect to find in these ill-farmed and unenlightened countries any instruments even remotely resembling the compact and powerful harrows of this country; instead of these the branch of a tree, or a few logs of wood fastened coarsely together, and dragged slowly over the surface of the very thinly and partially disturbed soil by oxen, are the only means employed to cover the seeds. These implements are thus described by Mr. George W. Johnson, in his "Essay on the Agriculture of India":— "When the plough has done its utmost on the stiff soils of Bengal, they still remain cloddy, and unfit to be seed beds. To remedy this, a still more imperfect implement than the Indian plough is employed, which is intended to produce the combined effects of the roller and the harrow. This is nothing more in form than an English ladder made of bamboo, about 18 feet long, drawn by four bullocks, and guided by two men, who, to increase its power, stand upon it as they direct and urge on the cattle. Again and again has it to pass over the same surface, and then, as in the case of their plough, it causes a great expense of time and labour, without any commensurate effect. The Indian ryots show their consciousness of the reason that the operation of pulverizing and levelling is beneficial, by calling it 'rasbandham,' that is, the confining of the moisture.

"And in countries somewhat more civilized, the construction of agricultural implements has hardly progressed more rapidly than in the East, for even in many parts of Europe they still use ploughs of the heaviest and most ill-constructed character. Their teams, too, are equally neglected; horses, cows, asses, and even goats, are harnessed together in a most wretched manner, as was the custom, it would appear, in very primitive times in Palestine. (Deut. xxii. 10.) The German farmers still use, instead of a plough, an instrument called a haken, which is exactly similar to one used by the Roman farmers. Their harrows have commonly only wooden teeth, and are worked with five horses in a very bungling manner. (*Johnson's Farm Encyclopædia*, p. 559.) And, still farther north, the Muscovite harrows are formed even in a ruder way, by merely fastening together the branches of the fir tree, whose projecting, partially trimmed spurs form the teeth, while the implement they use for a plough is little more than a shapeless bundle of sticks tied together with tarred rope.

"It is curious to trace the progress of plough-making in England. Those of the early cultivators were of necessity rude and imperfect, for

in those days the ploughman made his own plough. A law of the earl Britons, in fact, directed that no one should guide a plough until he wa able to make one. The driver was, by the same law, to make the trace by which it was drawn, and these were to be formed of withes of twiste willow, a long exploded custom, many of the olden terms of which, how ever, are still retained by the rustic ploughman. Thus the womb-with is yet called the wambtye or wantye. Withen trees are denominate witten trees, or whipple trees," &c. Such were the implements, suc the harness of our forefathers, when they were only just beginnin to progress in the cultivation of the earth, and to live together in labour dividing masses.

The modern farmer will hence pretty accurately estimate the kind o rude ploughs, and the great amount of unnecessary labour they would need, to accomplish a given amount of work in the days to which we have referred. This property of the plough is one even now not nearly so generally regarded as is desirable; yet these have not unsuccessfully engaged the attention of more than one great farmer, and some of the general comparative results of their experiments I now proceed to examine. The farmer will remember that these can only be comparative; for it is idle to conclude that the plough, which excels all others in the smallness of the power needed to accomplish a given amount of work, shall be equally successful in all soils and situations. The chief use, then, I repeat, of these experiments is to show, not only that there is a very material difference, but how very considerable that difference is, between one variety of the same implement and another. This great question engaged the earnest attention of the late Henry Handley, one to whom agriculture is under very considerable obligations. He tells us (*Jour. R. A. S.* vol. i. p. 142) that, in order to satisfy himself more particularly as to the draught of ploughs, he requested the Messrs. Ransome, of Ipswich, (who are the most extensive manufacturers of ploughs in the kingdom,) to furnish him with the opportunity of ascertaining the fact in respect of those implements which they themselves had constructed. A stubble field of a sandy loam was selected; partly up and down hill, and partly on a level. The ploughs, all by the same maker, were set to the same gauge, viz. furrows six inches deep and ten wide, drawn by a pair of horses abreast, and held by the best men that could be procured, who were occasionally changed from one plough to another; and the same draught dynamometer was used in all the trials. The following mean results were under these circumstances obtained, the length of the field and back being the trial in each case:—

Plough.	Maker.	Weight. cwt.	qr.	lb.	Draught. cwt.	qr.	lb.
Rutland (with wheels) . .	Ransome, N. L.	1	3	22	2	1	21
Bedfordshire (with wheels)	Ditto, L. L.	1	3	26	2	3	24
Lincolnshire (swing) . .	White, with Ransome's irons, B.M.	1	0	18	3	0	0
Lincoln Heath	Ditto, L. H.	1	1	1	3	0	11

The trials of Mr. Handley prompted Mr. Pusey to institute a similar and still more elaborate series of experiments; and he soon found a Berkshire plough in his own neighbourhood of very superior lightness to any he had yet noticed. The results of his trials (*ibid.* 221) are given in stones; they are chiefly valuable as affording comparative evidence. In a trial between Hart's and two of the Messrs. Ransome's, he found that the required draught was as follows:—

Hart's	1½ cwt. equal to	15 stones.
F. F. swing	3	24 ,,
Rutland	3¾	30 ,,

It was determined in these trials, amongst other things, that the surface draught (that is, the draught which the plough requires in merely passing over the surface of the ground, or along an empty furrow) differs very materially; the results of their surface trials (being, as before, given in stones) were as follows:—

Ferguson's swing, weighing	15 stones, draught	12 stones.
Clark's swing	15	12 ,,
Hart's wheel	12	3 ,,
F. F. wheel	13½	8 ,,
F. F. swing	10½	10 ,,
King's swing	8	8 ,,
King's wheel	10	6 ,,
Old Berks wheel	10	8 ,,
Rutland wheel	15	8 ,,

That this surface draught should bear so very considerable a proportion to the entire labour of the whole task of the horse is very remarkable, for, after deducting this surface draught there remained, Mr. Pusey found, in ploughing a furrow on a sandy field at Hatford 9 inches broad by 5 inches in depth, only the following amount of required draught:—

	Stones.
Ferguson's	7
Clark's	5
Hart's	9
F. F. wheel	5
F. F.	6
King's swing	7
King's wheel	12
Rutland	8
Old Berkshire	13

The young farmer must not suppose that the amount of the required draught increases in exact proportion with the depth and breadth of the furrow, for such is not the case. In several trials made with various ploughs at different depths, the following results (in stones) were obtained on a free brown loamy sand, of good quality:—

Ploughs.	Furrows.			
	4 by 9	5 by 9	6 by 9	7 by 9
Ferguson's Scotch swing	18	19	19	22
Clark's ditto	17	17	18	21
Hart's 1 wheel	11	12	16	18
F. F. Ransome's 2 wheels	12	13	18	21
F. F. Ransome's swing	16	16	18	21
King's swing	15	15	18	20
King's 1 wheel	16	17	21	23
Rutland, N. S., 2 wheels	16	16	18	20
Old Berks	21	21	24	31

The retarding effect of the adhesion of the soil to the surface of the plough is not only very considerable, but that adhesiveness varies in degree not only with different soils, but according to the material of which that surface is composed. Professor Schubler has investigated this important subject with iron and wooden surfaces, and in different kinds and states of soil. Of the results he obtained, he says, (*Jour. R. A. S.*

vol. i. p. 188,) when speaking of the consistence of soil in the moist state, and its attachment or adhesion to agricultural implements, "When land is worked in a wet state, we have not only to overcome the cohesiveness of the particles among themselves, but at the same time their attachment and adhesion also to the agricultural implements employed. If we wish to subject this property to a comparative trial, we may effect it in the following manner. We fasten large round plates, equal in size, made of iron and wood, (as the two materials commonly used for agricultural implements,) underneath the scale-pan of a balance, and put weights into the other scale until both are equally balanced; we now bring the plate into exact contact with a moistened earth lying beneath it, and put weights into the other scale-pan until the plate is drawn away from the earth; the amount of such weights corresponds to the degree of adhesion, or to the difficulty of working the earth in its wet state; the degree of this adhesion is often more considerable than would have been expected—an adhesion plate of three or four square inches required upwards of two ounces of counter-weight in order to draw it away from the surface of garden-mould: in the case of the heavier clays, the weight required was as much as five or six ounces. From the size of the plate employed in this experiment, it is of course easy to calculate the amount of adhesion for larger or smaller surfaces.

The following table contains the results derived from experiments made according to the foregoing plans, on the firmness and consistence of earths; the amount of adhesion in the wet state is calculated in pounds on a surface of one square foot. The "firmness" column indicates the weight required to force into perfectly dry specimens of the earth a little blunt spade "of steel," $\frac{1}{36}$ part of an inch in thickness, and $\frac{1}{5}$ of an inch broad.

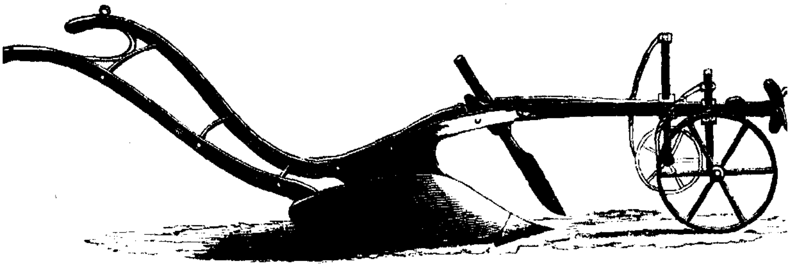
Kinds of Earth.	In the Dry State.	In the Wet State.	
	Firmness, that of Clay being 100.	Adhesion to Agricultural Implements, on a surface of 1 square foot; with	
		Iron.	Wood.
Siliceous Sand	0	3·8 pounds	4·3 pounds
Calcareous Sand	0	4·1 ,,	4·4 ,,
Fine Lime	5·0	14·3 ,,	15·6 ,,
Gypsum Powder	7·3	10·7 ,,	11·8 ,,
Humus	8·7	8·8 ,,	9·4 ,,
Magnesia	11·5	5·8 ,,	7·1 ,,
Sandy Clay	57·3	7·9 ,,	8·9 ,,
Loamy Clay	68·8	10·6 ,,	11·4 ,,
Stiff Clay or Brick-earth	83·3	17·2 ,,	18·9 ,,
Grey pure Clay	100·0	27·0 ,,	29·2 ,,
Garden-mould	7·6	6·4 ,,	7·5 ,,
Arable Soil	33·0	5·8 ,,	6·4 ,,
Slaty Marl	23·0	4·9 ,,	5·5 ,,

These researches are too important in their objects to need any observations of mine to commend them to the reader; they are directed to the accomplishment of reduced expenses, and lessened efforts of the farmer's horses. On the score of science, economy, and of humanity, then, I suggest the employment of the dynamometer to the young farmer; he will soon find by its aid, and even by only the aid of the quick discernment of an experienced ploughman, which plough it is that

will best suit the soil of his farm, and thus he will be enabled to award the justly earned preference to those great implement makers who have so laboriously, and so successfully, combined "science with practice," in the improved construction of not only the plough, but of almost every other implement of agriculture.

In attempting to give the young farmer an outline of the present state of our advances in the improvement of agricultural implements, I think it may not be unattended with benefit if I adopt the course of following the progress of the cultivation of an arable field from the time that it is first broken up until the period that its crop is carried to market, and of noticing some of the chief implements which are commonly used to effect the great object "of doing the work in the best manner, at the best period." If, in following this course, I am compelled (as I can only give one or two drawings of a class of implements) to omit the valuable implements of several great makers, they must attribute the omission, not to any insensibility on my part of their value, but to the limited space assigned to me in this section.

The first operation, then, is to break or plough up the soil. To accomplish this we have, amongst many excellent modern varieties, the prize ploughs of the Messrs. Ransome, of Ipswich; and Howard, of Bedford.



[*Ransome's Prize Plough.*]

In his report, made to the Royal English Agricultural Society, of the implements exhibited at the Southampton meeting, Mr. Joseph Parkes has pretty clearly described the merits of this plough. He observes, (*Jour. R. A. S.* vol. v. p. 367,) "The judges having selected from the immense number of ploughs exhibited, such of them as they deemed particularly worthy of trial, these were apportioned to the light or stiff land farms according to the wishes of the exhibitors. At the time of trial, each plough had a separate land assigned to it, and each ploughman was desired to execute the best work he could without regard to quantity, the excellence of the performance being the object principally sought. Some of these ploughs were entered as wheel-ploughs only; some were represented to work with two wheels, or with one wheel, or as swings; others were constructed purely on the swing principle. Under these circumstances the judges thought fit first to order the two-wheel ploughs into action, then those with one wheel, and then the swing, or the ploughs without a wheel. By this arrangement not only was the quality of the work done by each implement separately displayed, but a fair opportunity offered itself for observing and comparing the quality of the work as executed in the same soil, and under the same circumstances, by the three classes of the implement. The skill of the individual constructor was also manifested; and, on this occasion, the

remarkable result came out that one particular plough excelled all the others, whether working with two wheels, with one wheel, or without a wheel. In each case the work done by this plough was unquestionably superior to that effected by any other competing with it; and it was equally unquestionable that the order of excellence, in respect of work, was—first, that executed by this plough when fitted with two wheels; secondly, with one wheel; thirdly, when acting without a wheel, or as a swing. This plough was one of three in the field, from the manufactory of Messrs. Ransome, marked Y. L.; and to them the judges awarded the Society's prize of ten pounds and the silver medal.

These remarks have reference to the trials made on the light land at Mr. Gater's farm; and precisely similar results were recognised by the judges on the trials which took place on the very hard stiff soil at Mr. Spooner's farm. Here again the superiority of the same plough developed itself; but, to meet the condition of the soil, Messrs. Ransome had fitted it with a longer and differently curved mould-board. To them the judges also awarded the Soceity's prize "for the plough best adapted to heavy land," as well as that for "light land." Some very good work was done on the light soil by ploughs manufactured by Mr. John Howard, of Bedford, and by Messrs. Sanders, Williams, and Taylor, of Bedford. On the stiff soil, the judges commended the performance of a plough by Messrs. J. and E. Plenty, of Newbury, (an old Hampshire implement,) and as being apparently of light draught; also a plough by Mr. Howard, of Bedford; both working with two wheels. The performance of the swing ploughs was very indifferent on both sorts of soil, excepting that of Messrs. Ransome's implement on the lighter soil.

In recording these trials, the writer, who had the advantage of attending the two judges of this department, and of communicating with them during all the trials, only repeats their sentiments in marking the difference of the work under the three varied applications of Messrs. Ransome's plough. When fitted with two wheels, its performance was like that of a planing-machine; the furrow slices were cut vertically from the land, the floors or bottoms were left perfectly flat and clean, and the slices were deposited at an angle of about 45° with such truth, that they could be turned back to their original horizontal bed without gaining or losing ground. According to the generally received principles of perfect ploughing, (whether they be correct, and equally suitable to all soils and modes of culture, or not,) it is imagined that practice has in this instance closely approached to their fulfilment.

When fitted with one wheel, though the work of the plough was excellent, yet there was an evident declining from that extreme regularity and finish belonging to the first performance.

When acting without a wheel, or as a swing, an effect was plainly discernible, and which is directly traceable to the influence exercised over the motion of the plough by the motion of the draught animals.. The floor of the furrows, though cut nearly as flat in its transverse section as in the two former cases, no longer presented so continuously even a surface as if fashioned by a tool travelling along and maintaining an unvarying plane; it was wavy, exhibiting short, burst, or broken surfaces, and answering to the impulses of the animals. Nor was this owing to want of skill in the ploughman, as compared with the skill of others who brought their best swing ploughs and their best ploughmen to compete for the prize, for the furrow bottoms of the latter were still more jagged and irregular. Had the light soil operated upon been in a

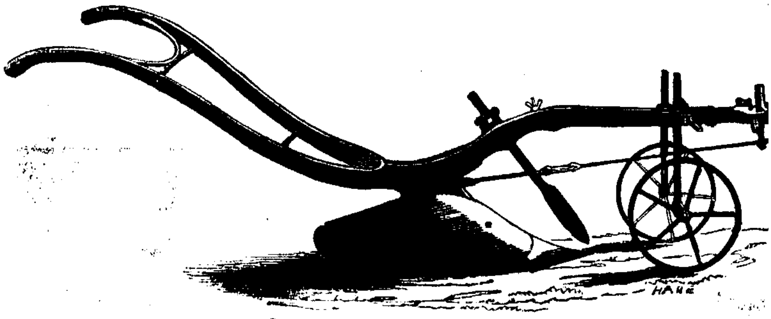
condition fit for autumnal ploughing, there can be but little doubt that all the swing ploughs would have acted better, and that less difference would probably have been perceptible in the quality of the work: yet the writer esteems it to have been advantageous to the progress of arable mechanism that these trials occurred at a period when the merits or defects of the ploughs were prominently brought out by the excessively baked state of the soil. On the hard land especially, (at Mr. Spooner's,) "proof of bottom" was obtained. Several of the ploughs would not enter the ground, nor work to the depth required; others were continually thrown up on the surface; and some were quickly crippled in one way or other. The test was certainly severe, but the merit of any plough was proportionably great which could perform good work under such circumstances.

The inquiries addressed to the judges and to the writer have been numerous, and very natural, as to how it happened that the same plough proved to be equally fit for light and heavy land? The explanation has already been partly given by the statement of the fact that Messrs. Ransome changed such parts of their plough as they deemed necessary to suit a change of soil; just as a skilful workman adapts his tool to the different nature of the materials under hand: and abundant proof was afforded to, and acknowledged by the judges, that one given form of mould-board is utterly inadequate to suit all soils. Much also of the success of the plough is due to the principles of its construction, as explained in the report of the Derby meeting. "In this," the judges observed, (*ibid.* vol. iv. p. 467,) "they would particularize as worthy of high commendation, those produced from the manufactory of Messrs. Ransome, composed entirely of iron and steel. The beams of these ploughs are constructed on the *truss* principle, which, though novel in its application to the plough, has long been appreciated by mechanics as possessing the greatest stiffness combined with lightness. It is this consideration which has induced those makers to abandon the use of wood, heretofore chiefly used by them for this part of the plough in preference to a beam of solid metal. The structure of their improved iron beam is such as to destroy lateral vibration, particularly at its root or junction with the body of the plough; it admits also of a neat and powerful fixing, as well as ready adjustment of the coulter.

"Tremor in mechanism is well known to consume power uselessly; and, in the case of the plough, vibration in the beam, though it be insensible to the eye, renders the guidance of the implement more difficult, and its work less exact. The circumstance of increased stiffness attending mere weight of matter, may have been one cause why the heavier ploughs have not unfrequently been found to require less force of draught than lighter ones, for an equal weight of soil moved; but stiffness is not incompatible with lightness, and a diminution in the weight of an implement, when perfect action is otherwise secured, must be attended with economy of power, or, what is the same thing, with a diminution of resistance, whence truer work results.

"It is also important that the stilts or handles should be stiff enough to transfer the effort of the holder to the body of a plough, with the least expenditure of his strength; for, the easier its guidance, the greater will be the certainty of the labourer's attention to his business. This property has also received the care of Messrs. Ransome, and, together with the simple means applied for adjusting and replacing the mould-boards, shares, and wearing parts of the various ploughs exhibited by them, testified to the thought and ability bestowed on the most

minute details of an implement which still maintains its claim to be th most indispensable, as it was probably the earliest invented, auxiliary t human labour in tilling the soil."



[*Howard's Prize Plough.*]

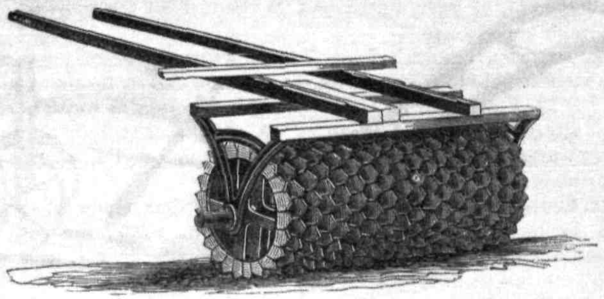
In the report of the implements exhibited at the Newcastle Meeting by Mr. Parkes, (*Jour. R. A. S.* vol. vii. p. 686,) when speaking of the various trials, it is said, " Ploughing was first commenced on the light land, seventeen implements having been selected for competition. The manifestation of superiority, in favour of the two-wheel ploughs made by Messrs. Howard and Co. of Bedford, was unquestionable, and in all the respects which would guide the judgment of a competent farmer in his choice of this important implement. They had two ploughs in the field, bearing the marks J. A. and H. L. It was to the latter plough to which the judges awarded the prize of 10*l*., remarking, ' that the sole of the furrow was cut perfectly flat, the land side clean and true, the furrow slices were laid with perfect uniformity throughout the field, and in a beautiful position for receiving the seed.' The J. A. plough was considered to be next in merit to the H. L., and but a trifling degree inferior to the latter. Fourteen ploughs operated upon the heavy land, and nearly similar distinctive characteristics were appreciated in the results, the judges again awarding the Society's prize to Messrs. Howard's H. L. plough, the work of the J. A. being next in quality. They gave it as their opinion, that no plough exhibited on this occasion possessed the power or construction to move soil to equal depth, and with the same precision, as Messrs. Howard's implements." (See " *Plough*," *British Husbandry*, vol. ii. p. 2.)

In the last few years the advantage derived from the deeper stirring of the soil has been successfully shown by Mr. Smith, of Deanstone, who produced his well-known subsoil plough. " Another, of a different and much lighter description," says Mr. J. A. Ransome, (*Implements of Agric.* p. 47,) " the invention of Sir E. Stracey, Bart., of Rackheath, is called by the latter name. It performs the operation of subsoil ploughing, to the depth of from ten to sixteen inches below the surface, and when preceded by the common plough, which is the plan recommended, the depth reached below the surface ground is just so much the more than the first plough effects."

SCARIFIERS AND CLOD CRUSHERS.

Following the order of proceeding in the cultivation of an arable field, the next implement, after the plough has been used in breaking up the soil, is to pulverize and cleanse it. This brings me to the clod crusher

of the heavy land farmer, to the scarifiers or cultivators of the holder of lighter soils. Of these, I shall select three of the first class, viz., the clod crushers of Crosskill, Stratton, and Cambridge, and the scarifiers of Biddle and Morton.



[*Crosskill's Patent Clod Crusher Roller.*]
Size, 6 feet 6 inches in width, with single shafts, weighing 27 cwt.

The patent clod crusher, as described by its inventor, consists of a series of cast-metal rings or roller parts, placed upon a round axle, and acting independently of each other, thereby producing a separate action in turning round upon the headlands without moving up the soil, and effecting a self-cleaning movement. The roller parts are 2 feet 6 inches in diameter, with indented or serrated surfaces, having a series of inner teeth placed at right angles to the centre of the axle, and pointing directly perpendicular into the clods, more effectually pulverising the roughest land into a fine uneven surface mould.

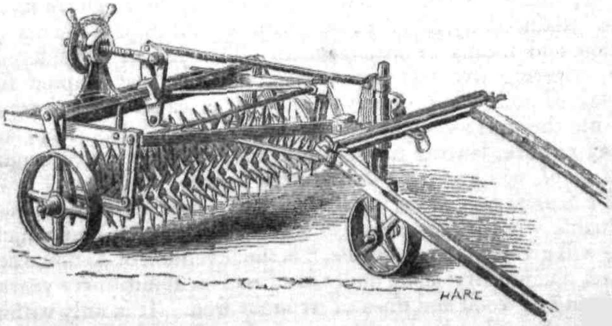
It is thus alluded to in the report of the implements exhibited at the Newcastle meeting, (*Jour. R. A. S.* vol. vii. p. 693,) when alluding to "*Clod Crushers and Rollers.*—In this department no competitor appeared against Mr. Crosskill's roller, of which he exhibited numerous specimens, varying in size and weight, and adapted to the different purposes to which experience has proved the implement to be usefully applicable. The sum of money placed at the free disposal of the judges being, on this occasion, much more limited than at previous meetings, and no prize having been offered by the Society for rollers of any kind, the judges appended to their list of awards an unanimous expression of the estimate formed by them of the merit of this clod crusher or roller, including a hope that the Council would reward its inventor with the Society's gold medal for its introduction, and for the several successive improvements made upon it by him. At a subsequent meeting, the Council, acting upon the recommendation of the judges, conferred this, their highest mark of distinction, upon Mr. Crosskill.

"The judges have further remarked in their communications with the writer, that 'they consider this implement, with its latest improvement, to be the most beneficial one used in agriculture exhibited at the Newcastle Meeting.' The improvement thus referred to, consists in the enlargement of the eye of each alternate ring, forming collectively the series of rings or discs of which the roller is composed; so that of these rings, which are 23 in number, 12 have eyes fitting the axle just freely enough to revolve upon it, whilst the 11 alternate rings have their eyes enlarged about half an inch more in diameter. This arrangement has added materially to the effect of the implement in abrading and reducing hard clods; it has also induced among the rings a more efficient self-

cleaning movement, when the roller is used on moister soils or softer clods; so that, practically, the scope and power of the roller have been augmented without adding to its cost, or impairing its extreme simplicity; and it can now be employed on soil when in states which would have clogged it, or have diminished its effect if all the rings on the axis had eyes of similar size*.

"The superior results arising from this disposition of parts are altogether attributable to what is properly termed *action*, mechanical action, and it has been owing to its possessing this function in so high a degree, of each alternate ring, which causes a kind of eccentric or up and down motion to take place between each pair, and among the whole series of rings or discs.

"Mr. Crosskill's square-axle toothed roller first made its appearance in the Society's Show-yard at Cambridge, in 1840; the round-axled patented machine at Derby, in 1843; a premium of 20*l.* was awarded for it by the judges at Southampton, in 1844; and it gained the Society's prize of 10*l.* at Shrewsbury in 1845, having on all occasions of trial at the Society's shows greatly excelled the performance of every other roller brought into competition with it. *Journal*, vol. iv. p. 560, contains a large collection of instances of its utility in arresting the ravages of the wire-worm, an effect owing probably to the forcible bite of the teeth on the ground, in the pulverization of stiff, and compression of light soils, together with the opinions of numerous agriculturists upon its value as a roller of various crops in a state of young growth. Its application to the latter purpose has greatly extended since that period, and the writer may bear his testimony to the success attending its employment on pasture-land in destroying the white slug, curing mossyness, and especially in consolidating soft grass-land after drainage. For these latter uses the effect of the implement is greatly enhanced by weighting it to the full extent of the power of the team which can be commanded."



[*Norwegian Harrow and Clod Crusher.*]

This implement is thus described in the report of the implements exhibited at the Shrewsbury Meeting of the Royal English Agricultural Society (*Journal*, vol. vi. p. 312):—"A harrow of an entirely novel construction, and of great promise, in the estimation of the judges, was exhibited by Mr. G. E. Frere, F.R.S. of Edinburgh, and attracted much attention in

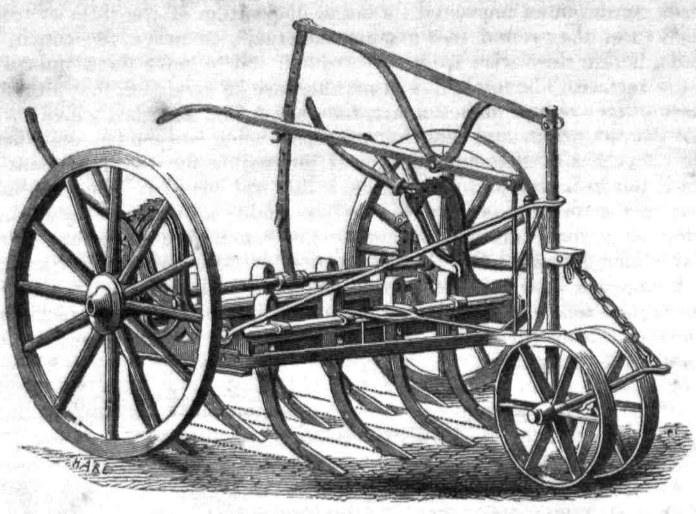
* This improvement was sugested to the patentee by Mr. Robert Neilson, of Halewood, near Liverpool.

the field. It is called the Norwegian harrow, or clod crusher, and was originally imported from Norway by Mr. Frere; the one under notice having been constructed, with some changes, by Mr. Richard Stratton, of Bristol. The acting part of this implement consists of a frame containing four horizontal spindles, on each of which is fixed a set of cast-iron bosses, with teeth projecting from them like the rowels of a spur. These teeth revolve with the spindles, those on one spindle interworking with the others, so that they severally clear and clean each other. The effect produced is a remarkable bruising, crumbling, or disintegration of the soil, without any clogging of the spikes, or possible derangement of the working parts. The weight suffices to cause the spikes to penetrate to the required depth, which is also governed by an adjustment of the wheels applied for travelling the implement, and for taking it out of work when turning; but it acted quite as well when divested of the wheels and of other paraphernalia, which tended rather to embarrass than assist its good action. Neither stones nor sods appear in any way to obstruct the working of this eminently simple machine, the stones being pushed aside, and the sods torn to pieces. The force was thought to be less than that required to work a common set of harrows going equal depth, and the effect in pulverization much greater. It was tried on two different kinds of soil immediately after ploughing, with similarly good results. To what extent this implement may act as a clod crusher the judges cannot say, as they had no means of trying it; but this distinction may be drawn between it and such an implement as Mr. Crosskill's, viz., that the Norwegian harrow leaves the land perfectly light and loose, whilst the clod-crushing roller gives to it firmness and consistence. The judges awarded to Mr. Frere a premium of 10*l.*, and Mr. Stratton obtained many useful hints, from this first trial of the implement, for its future improvement."

These hints, it seems, were not lost sight of; for in the Report of the meeting at Newcastle, (*ibid.* vol. vii. p. 688,) it is said, "The Norwegian Harrow, which created so much interest at the Shrewsbury meeting, was again produced by Mr. Stratton, with several improvements in its construction and means of management. The judges considered the specimen, covering five feet in breadth, to be the best adapted for all descriptions of soil; and observed that it is capable of thoroughly breaking up the furrow-slices from three to six inches deep, as the farmer may require, leaving the soil in beautifully pulverized condition. An award of 5*l.* was given to Mr. Stratton for this implement."

Biddell's Scarifier.—"This implement," observes Mr. J. A. Ransome, in his valuable work, (*Implements of Agriculture*, p. 79,) of which the engraving will give a general outline, "is the invention of Arthur Biddell, of Playford, and was first made under his direction about thirty years ago, with a framing of wood and tines of wrought iron. It is only within the last few years that it has been made principally of cast iron, and generally introduced. It consists of a very strong cast-iron frame, upon which the teeth, nine in number, are arranged in two rows, and so disposed at intervals of 16½ inches from each other, as that those in the hinder row should form a path midway in the intervals left by the passage of those in the front. It is suspended on a cranked axle between two wheels, fifty inches in height behind, and on an upright shaft, carried on two small wheels running close together in front. It will be seen that the machine is thus suspended on three points, and by means of two levers, the one to direct the position of the front teeth, and the other to regu-

late the depth of the hinder ones, it may be balanced between these points in any direction that may be required.



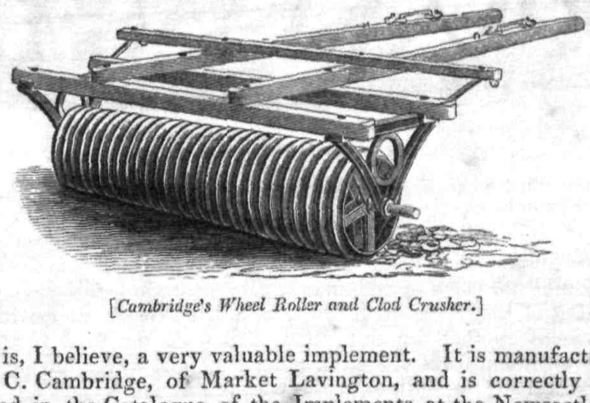
[*Biddell's Scarifier.*]

"It may thus be used either with the fore tines parallel with the hinder ones, or at a greater or less depression; this arrangement allows it to penetrate very strong or hard land, and to retain its hold when scarcely any other implement would produce any effect, and even when the plough could not work to advantage. By a simple contrivance to shift the bearing of the frame upon the axle, either side of the machine may be depressed so that the tines shall penetrate the land to a uniform depth, even when, from the circumstance of one wheel having its path along the furrow, the bottom of the wheels may not be parallel with the general level of the land. The tines are prepared to fit case-hardened cast-iron points, of one, two, or three inches width, or cast-iron or steel hoes of nine inches width; with these latter every part of the land will be cut. They are readily taken off and exchanged."

[*Morton's, or Uley Cultivator.*]

"The Uley Cultivator," remarked the judges of the English Agri-

cultural Society, (*Jour.* vol. ii. p. 109,) "invented by Mr. Morton, of Chester Hill, is an implement of great strength and utility: its peculiar merits consist in an improved form and disposition of the tines or teeth, which enter the ground in a manner effectually to move the couch, or weeds, before they arise from the ground, and to leave them unbroken on the surface. The teeth, five in number, are so arranged, that although drawing lines only 8 inches apart, they are 2 feet asunder, which, with their curved shape, and length, and their being suspended on wheels 3 feet 4 inches in diameter, renders it impossible for the implement to choke, however foul and encumbered the soil may be. The depth to which the teeth are let into the soil is readily determined by a winch acting on a worm and wheel; and by the same means they are raised clear of the ground. For the preparation of light soils for barley, the teeth are provided with cast-iron shares, which effectually shallow-plough the surface without reversing it. Points of different widths, and also steel blades for paring, are furnished to fit on the tines without pins or other fastenings.



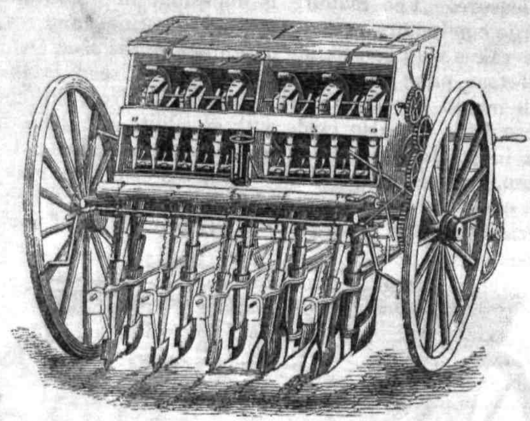
[*Cambridge's Wheel Roller and Clod Crusher.*]

This is, I believe, a very valuable implement. It is manufactured by Mr. W. C. Cambridge, of Market Lavington, and is correctly enough described in the Catalogue of the Implements at the Newcastle Exhibition, "as being serviceable on all lands: for light lands to make them firm, and prevent the ravages of the wire-worm and grub; on hill farms for pressing and preventing the dust flying, and leaving the roots of the plants bare; and it is usefully applied to wheat in wet lands." (See *British Husbandry*, vol. ii. p. 33, "Rollers.")

DRILLS AND DIBBLING MACHINES.

The ground, then, being prepared for the reception of the seed by the operation of the plough and the cultivator, this brings us, in the course of the examination which I proposed, to the implements by which the seed and, if needed, its manure is best deposited. This leads me to the drills and dibbling machines. I can only select, for the farmer's inspection, one or two of this valuable class of machines. (See "Drilling," *British Husbandry*, vol. ii. p. 72.)

As the manufacturer of the valuable Suffolk machines very correctly remarks when describing drills, (and see *post*, *Drill Manures*,) which are so well adapted for the deposition of, 1, manures and seeds; 2, corn or grass seeds alone; or 3, for turnip or mangold-wurtzel seeds and manure, "the merits and form of the Suffolk corn drill are familiar to agriculturists generally, it remains therefore but to point

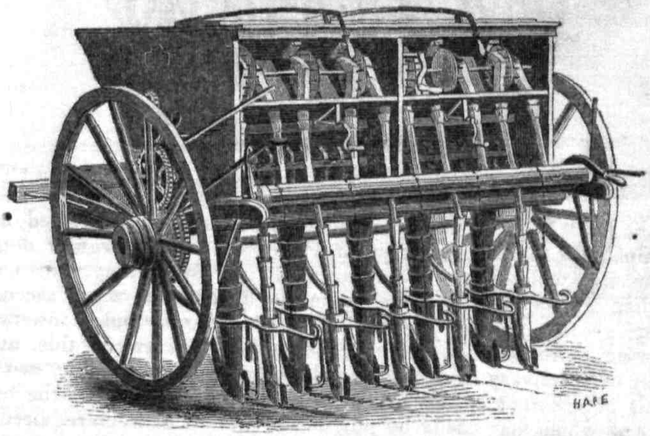


[*The Drill for general purposes, of Garrett and Son, of Leiston, in Suffolk.*]

out the latest improvements. Among these may be enumerated, as the principal, the simple apparatus provided to ensure a regular delivery of the seed when going up or down hill: in descending, a drill has a peculiar tremor, and a tendency to go faster than when ascending, giving greater velocity to the delivering cups, and consequently throwing more seed down the conductors. To remedy this, and to render the delivery from the barrel as uniform as possible, two cog-wheels of different speeds are placed one on each end of the barrel, either of which may easily be put in and out of gear, as required, and worked from alternate ends—the small wheel when going up hill, and the large wheel when going down. The seed-engine accompanying this drill is adapted to sow at the same time with spring corn, or may be used as a separate implement for grass seeds, broadcast, or turnips and mangold-wurtzel in rows. In order to ensure an equal delivery of the different kinds of seed, the box is partitioned off into two departments, one for heavy seeds, such as clover, trefoil, &c., and the other for the lighter seeds, such as rye-grass; the former being delivered from cups, and the latter from brushes, down the same conductors with it. Thus the required quantities of each seed are nicely mixed and evenly sown all over the land, and may be regulated by turning the screw at the end of the box for rye-grass, and changing wheels on the cup-barrel for clover, &c.

"By the new steerage machinery, which acts as a fore carriage to the implement, a man may keep the rows of corn perfectly parallel with the preceding course of the drill. This is done by a man holding the steerage handle, and keeping the small fore wheels in the track of the former large one. This, with a little practice, is very easy, and will amply repay by the perfect regularity in the crop, affording the greatest facility for the horse-hoe going between all the rows of plants, and with equal precision, where the drills join in their different courses through the field. The swing steerage, at a less cost, and managed without an additional attendant, is amply sufficient where the drill covers each stetch, or land, in twice. Lastly, as a turnip and manure drill, it may be used to suit all methods of cultivation, whether on flat lands or ridges, as the axletree may be made to slip, so as to alter the sizes to the different widths of ploughing. The distances of the rows may be

varied at pleasure. The manure is deposited in a continual stream down the large conductors in any required quantities, and covered with the drags or rakes with soil to any depth before the seed (which passes through different pipes) is sown upon it; the seed is then lightly covered with mould by chain harrows suspended from the end of each lever. These drills are also made with an addition to drop the manure and seed at intervals, through separate conductors, instead of a continued stream, by means of which expensive manures may be much economised, one-third or half the quantity generally used being, by this means, sufficient to afford every plant its full proportion of nourishment."

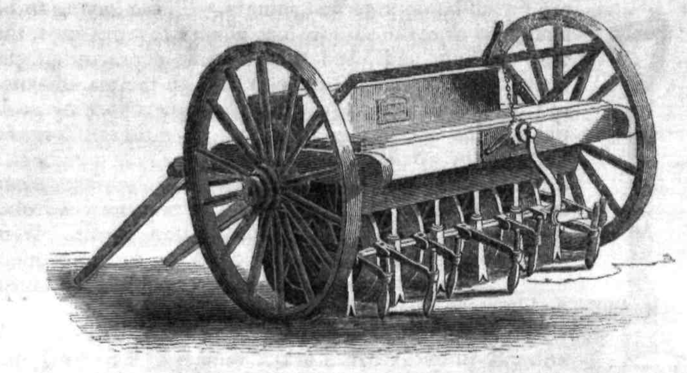


[*The Drill for general purposes, of Mr. R. Hornsby, of Grantham.*]

This valuable drill is thus tersely described by its owner as an "eleven-coulter corn and seed drill, 72 inches centre of carriage wheels, fitted with iron levers, and an additional ten-row manure box, ten manure coulters, and tins complete, for drilling corn and seed, with or without bones, rape cake, or any other pulverized manure, in a moist or dry state. This drill had the prize of 15*l.* awarded to it, as the best drill exhibited at the meeting of the Royal Agricultural Society of England, at Newcastle-upon-Tyne, July 1846, and was also selected by the judges of the Royal Agricultural Society of England, at Shrewsbury, July 1845, for subsequent trial, which trial took place on the 23rd and 24th of October, 1845, upon the estate of P. Pusey, Esq., M.P., at Pusey, Berkshire, and had the prize of 15*l.* awarded to it, as being the best drill for general purposes."

"These drills," remarks Mr. Parkes in his Report, (*Jour. R. A. S.* vol. vi. p. 317,) "were severally and carefully worked, both with dry and with moist manures; and the Society's prize for each class of drill was adjudged to Mr. Hornsby, the judges being of opinion that his drills were more open and simple, and more completely accomplished the desired purposes, than those produced by any other exhibitor."

"A premium of 10*l.* was awarded," remark the judges of the Shrewsbury meeting, (*Jour. R. A. S.* vol. vi. p. 315,) "to Mr. William Edward Vingoe, of Penzance, Cornwall, for an implement entered as a seed-depositing or planting machine, but which may be properly treated under the class of drills. This implement, then a recent invention, was first brought to the notice of the Society at Southampton, re-appearing at



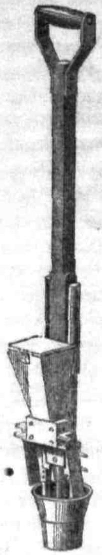
[*Vingoe's Seed Planting and Manuring Machine.*]

Shrewsbury with several important additions and improvements. It there enlisted the judges' earnest attention, and received their unqualified admiration from the simplicity of its acting parts, the accuracy of its deposition of seed, and the mechanically good adaptation of means to ends. Although simple, it is difficult to describe. It travels on three wheels, the leading pair being attached to the shafts, from which pair is derived the small power required to effect the measurement and deposition of the seed. The machine exhibited was capable of sowing six rows of corn or other seed at a time. The apparatus for forming the drills consists of six pressing-wheels, immediately followed by as many narrow hollow boxes or shares, which maintain the little trenches clean and open, and each trench perfectly distinct, until the seed falls into them. Through these shares the seed is conducted by small tubes from the seed-box or hopper above them; and immediately behind the shares is placed a peculiarly simple and effective kind of hoe for covering the seed. The seed is received upon sliders resting on the bottom of the hopper, and furnished with proper recipient holes, the size of which determines the number of seeds desired to be planted. Means are provided for striking off excess; and it was found, on repeated trials, that no greater difference took place in the number of seeds deposited than was fairly attributable to the difference in magnitude of the corns. The apparatus is readily raised out of the ground at headlands or when turning.

"This machine is especially recommended by the judges to the notice of those agriculturists who have the means and wish to assist in developing and proving the merits of new inventions. If the preparation of a firm seed-bed be a good principle, this machine effects it as well as any presser—pressing and drilling six rows at once, with an adjustment for shifting the widths of the rows from five to any other number of inches apart desirable for grain; and it either distributes the seed in a train, or drops it within a small compass."

DIBBLING MACHINES.

Many, and not altogether unsuccessful, have been the modern attempts to produce a good dibbling machine to be worked by animal power; still, however, none of these have yet possessed sufficient merit to ensure their extensive introduction. "The great practical difficulty attending the construction of these machines," observes Mr. Ransome, (*Implements of Agric.* p. 117,) "rests on the circumstance that, to ensure accuracy in the deposition of such small quantities of seed, the mechanical arrangements



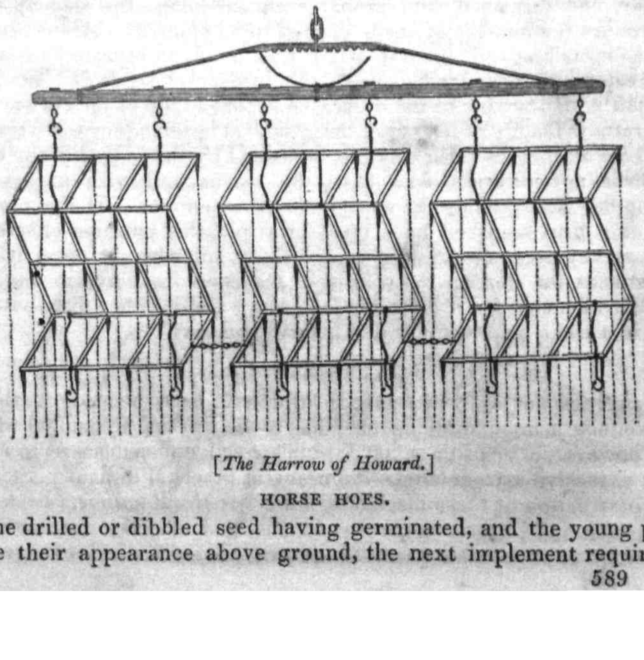
[*Crawford's Dibbling Machine.*]

require to be delicate and minute. These having to be placed so near the soil, in fact almost to work in it, the dust on light soils, and the adhesive character of the heavier soils, are alike impediments to the maintenance of the more delicate parts in their proper working positions. The motion required for the operations of forming the hole, by giving the dibble a twist or half turn before leaving it, and the necessity to deposit the seed precisely in the spot prepared for its reception, necessarily involve a somewhat complex mechanical arrangement. With *hand-dibbling* machines the success of the implement maker has been more considerable, several very useful dibbling machines having been produced.

In the Report of the Newcastle meeting, (*Jour. R. A. S.* vol. vii. p. 690,) Mr. Parkes remarks, "Several machines were exhibited for abridging labour of this kind, and for regulating with more precision than hand-dropping has yet done, the number of seeds deposited. The prize was given to Mr. Crawford of Birmingham, and principally because of his implement dropping into one hole a fewer number (yet enough) of seeds than others. The number of corns deposited in 11 successive holes by this machine was as follows :—2, 1, 2, 1, 3, 2, 3, 3, 1, 4, 5. (*See* "Dibbling," *British Husbandry,* vol. ii. p. 82.)

HARROW.

The seed being deposited in the ground, we next need the harrow, either to cover the seeds or to reduce the inequalities of the surface. (*See* "Harrows," *British Husbandry,* vol. ii. p. 22.) Of these excellent and improved implements, I shall merely give an engraving of one modern variety, viz., that made by Mr. Howard of Bedford.



[*The Harrow of Howard.*]

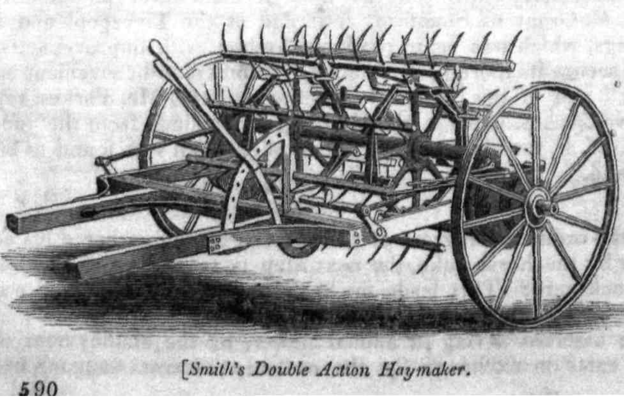
HORSE HOES.

The drilled or dibbled seed having germinated, and the young plants made their appearance above ground, the next implement required to

cleanse the soil from weeds, is the horse hoe. Of these implements there are several excellent varieties. (See "Horse Hoes," *British Husbandry*, vol. ii. p. 30.) One of the best of these is that made by the Messrs. Garrett, of Leiston, in Suffolk. This valuable implement is thus described, on several different occasions, by the judges of the implements exhibited at the meeting of the Royal English Agricultural Society:—"An implement that will greatly tend to give an horticultural finish to field operations. It is adapted to all the prevailing methods of drill culture, either for the cleansing of crops, drilled upon the level surface, or on ridges, the axle of the wheels being moveable at both ends, to suit the varied intervals between the rows of plants; and as each hoe works on a separate lever, the weeds are effectually destroyed, however uneven the surface of the ground, each hoe being kept at a uniform depth by means of regulating keys. The swing steerage adapted to this implement is a valuable addition to horse hoes, as they may thereby be guided with the greatest precision, perfectly scarifying the intervals, without the possibility of injuring the corn or plants." (*Jour. R. A. S.* vol. ii. p. 110.) "Still further improved, it was again selected for the Society's premium, as eminently calculated to answer the various ends to which it is applicable." (*Ibid.* vol. iii. p. 344.) "Rewarded both at Liverpool and Bristol, it was exhibited with improvements, rendering it still more complete in its fittings and adaptation to follow the drill in the various forms of culture to which the latter implement is applied. The silver medal was awarded for these improvements." (*Ibid.* vol. iv. p. 482.) Mr. Pusey, when speaking of horse-hoeing flat drilled turnips, remarks, (*ibid.* vol. iv. p. 77,) "As any mere trials, however, are less satisfactory than the actual work in a farm, I have obtained an account of its working from practical authority, and the following statement of its performance will, I trust, be satisfactory. Several farmers, I know, regard this horse hoe as one of the best implements lately invented. On an arable farm of 400 acres, the price, which varies from 19*l.* to 13*l.* 10*s.* might be saved by its use, I should think, in the first season."

HAYMAKERS AND HORSE RAKES.

Having now finished my survey of the modern implements which are employed in the cultivation of a *growing* crop, the next series are those required to *harvest* it. This class includes the haymaker, the horse rake, and the cart. (*See* "Hay Spreading Machine," *British Husbandry*, vol. i. p. 494.)

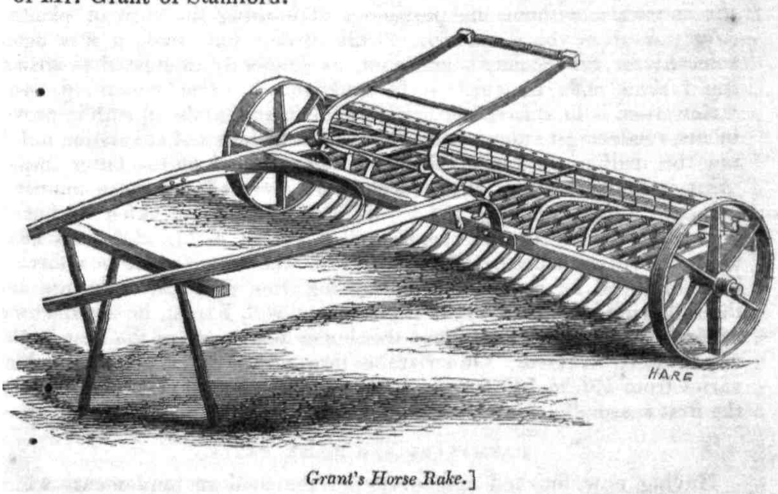


[*Smith's Double Action Haymaker.*

This machine has been lately much improved by Messrs. H. Smith and Co. of Stamford. For this, the judges of the implements at Newcastle (*Jour.* vol. vii. p. 685) awarded a prize. Messrs. Smith describe the objects of these improvements pretty correctly, when they remark, "*Now, one* man *alone* is necessary to work it, who has never occasion to leave his horse, as it can be *instantaneously* and with the *greatest ease* raised from, or lowered to, its work, and as quickly also, and as easily, it may be thrown in or out of gear, or the action of the teeth reversed, thus ensuring great saving of time and labour, much obviating the liability to injury and dilapidation, and saving the labourer from the imminent peril to which even a careful and skilful man has been hitherto exposed in the management of this desirable implement."

HORSE RAKES.

Of modern horse rakes I will give an engraving of one variety, that of Mr. Grant of Stamford.



Grant's Horse Rake.]

Of this excellent implement the judges of the Royal Agricultural Society remark, in their Report of the Derby show, (*Jour.* vol. iv. p. 483,) "Several horse hay-rakes were exhibited, but the judges adhere to the opinion formerly expressed, that none of them excel the patent rake of Mr. J. C. Grant of Stamford, rewarded at the Liverpool and Bristol meetings, which was again produced by him, with improvements, tending to secure its more perfect action, durability, and convenient management;" and of the Newcastle meeting in 1846, Mr. Parkes reported, (*ibid.* vol. vii. p. 690,) "Mr. Grant again obtained from the judges an award of *3l.* for his excellent horse rake, which was found to be much improved."

CARTING.

In the ordinary progress of the harvest, having gathered his corn together by the horse rake, the next step is to carry it to the barn or the stack-yard. This leads me to the question of carts and waggons. (*See* "Carts and Waggons," *British Husbandry*, vol. i. p. 153.)

The asserted saving in animal power, by the employment of one-horse carts in exchange for the ordinary harvest waggon, has now,

for some years, been the subject of occasional discussion amongst the farmers of England; the common result of which has been, to convince pretty generally the English farmer, that on most soils and in many situations, for the general purposes of agriculture, there is a very material saving to be accomplished in horse labour, by their employment in preference to waggons. "I early felt convinced," said Mr. Mechi, in the course of some observations he made in 1847, at a monthly meeting of the London Farmers' Club, "that it was much easier to carry a load upon an implement which weighed 7 cwt. running upon one pair of wheels, than upon one which weighed 22 to 24 cwt. running on two pairs of wheels; my powers of calculation were sufficient to convince me at once that we had been committing a perfect barbarism in the matter of waggons." And he alluded with advantage to a valuable paper by Mr. Hannam, on the use of one-horse carts, which some years since appeared in an early volume of the Journal of the Royal English Agricultural Society (vol. ii. p. 73). In this very excellent paper Mr. Hannam truly states that the farmers of the counties of Cumberland and Westmoreland have universally, and from time immemorial, used the one-horse cart; "they have no other carriage for any kind of agricultural produce, and never is the addition of another horse on any occasion seen. The practice, apparently originating in economy, has long since spread into the neighbouring Scotch county of Dumfries, and I have the authority of Mr. Wilkie, the well-known implement maker of Addington, near Glasgow, for saying that it is all but universal at the present moment throughout the west of Scotland." As relates to the economy of the cart, it is evident that a considerable saving in the expense for animal labour on a farm may be often accomplished by substituting one-horse carts for waggons. "I had no other object in entering into this practice," adds Mr. Hannam, "than lessening my expenses by reducing the number of my horses, and in this I have succeeded beyond my expectations. My farm (at Burcott, in Oxfordshire) of 370 acres, consisting chiefly of gravelly and ferruginous sandy loams, was some years ago under very able management, with a strength of 12 horses and 6 oxen; and just previous to my taking it into my own cultivation, 16 horses had been employed by a very spirited cultivator. I have gradually, by the joint operation of two-horse ploughs and single-horse carts, reduced my number to 8 horses. My system, notwithstanding, is such as somewhat increases my aggregate amount of horse labour beyond that of the surrounding district; certainly doing a great deal more carting work, although in a few points of tillage it is transferred to the manual labour. For instance, I grow annually about 35 acres of mangel and 20 of potatoes, which necessarily cause much carriage, and, together with the other ridged crops, also a good deal of horse-hoeing." The general saving of animal power has been thus stated in a tabular form by Mr. Hannam, and I am always glad when I can avail myself of such condensed statements, since it is general results which are commonly the most practically valuable. Mr. Hannam calculates that the team labour per cent. expended, with four horses, on a farm of 100 acres, is commonly thus apportioned:—

In ploughing . . . " horse-hoeing . . " dragging . . . " Suffolk drill, &c. .	about 50 per cent.
" harrowing . . . " rolling	" 12 per cent.

In carting . . . . about 38 per cent.

And that the saving capable of being effected is—

By two, and occasionally one-horse ploughs, and double-ridging ploughs . . . . By forking couch grass . . . . By pair-horse cat's-claw drag	27 per cent.
By one-horse 6 feet heavy roller, being 33 per cent. in the implement, and 10 or 12 per cent. on the general labour where heavy rolling is performed	1 per cent.
By single-horse carts	19 per cent.
Being equal to a total saving of . .	47 per cent.

"Let me now answer the question," continues Mr. Hannam, "which will be asked. In what manner is the saving by single carts of about one-fifth of the usual proportion of horses effected? By considering that to move a bulk from one spot to another, in the way that field operations are carried on by a continuous chain of loading at one end and discharging at the other, seldom less than three carts are employed, and that in the usual practice of the southern counties, one horse occupies the stand-cart or waggon, and three horses each of the other two that are in motion; the work thus going forward with seven horses. If two horses in a cart are used, five will be the number engaged; and if four, the number will be nine. Now, I am prepared to show, not by any series of experiments, but by the routine of my farm for the last ten years, that the same amount of work, when at a moderate distance, may be performed by three horses in separate carts; and that it is only at the greatest distance in which three three-horse carts are able to keep up the chain, that four may be required. And these will keep the same number of (and from low-filling, somewhat fewer) loaders engaged, and consequently accomplish the moving of an equal bulk. As this may seem a little paradoxical, I will enter into the reasons which combine to effect it. 1st. A horse thus harnessed draws more in proportion with equal ease; 2ndly, the misapplication of his strength in the constant draught of a heavy carriage is prevented; 3rdly, he moves more briskly and freely, and turns, &c., with less loss of time, and when any check occurs the loss is saved that takes place by the hindrance of a large number; and lastly, there is a certain convenience and ready manageableness which can be better felt than calculated or described.

"Practice and general opinion are agreed in assigning a greater power of draught to a horse working singly than to any number harnessed together; but the amount of difference I have never proved by actual experiment. Mr. Culley, in his Report of the three English border counties, gives an instance (p. 192) in which the advantage is as three to four (see also p. 272, and the Middlesex Rep. pp. 108, 526); and another, in which, with a horse of 16 hands, 24 cwt. was the load, on the hilly* road from Hexham to Newcastle. I am in the regular

* I had occasion to send my skeleton cart with 15 cwt. of hay up the steepest hill (Cuddesden) in this part of the country, and directed a very intelligent labourer to go with it and report: his statement was, that besides observing at a steep descent that the breeching was tightened more than the backchain, on stopping on the sharpest ascent he found the breast-

practice of sending out to any distance, on a turnpike however hilly, 5 qrs. of wheat, which, with the cart, 8 cwt., seldom amounts to less than 30 cwt. It is also considered universally, that the nearer a horse is to his load the easier will be the draught, but to what extent I have never proved.

" The misapplication of power caused by a heavy carriage is often enormous, there being sometimes, especially by waggons in harvest, double the weight of timber moved, in going backwards and forwards, to that of produce brought home; for instance, a common harvest-load, except at a great distance from the homestead, seldom exceeds one ton, and one ton more or less is the weight of a waggon: at any rate, 1 to 1 is the common proportion of the carriage to the harvest load. It is admitted that there is no perceptible difference between the size of my neighbours' loads and my own; the weight of my harvest cart I have stated is about 6½ cwt., therefore my proportion is 1 to 3; and under less favourable circumstances than mine, it need never, with a similar carriage, be less than 1 to 2; and this goes a very considerable way to explain why I am able to perform the same work with half the strength, and without straining the powers of my horses. In the dung-carts the case is not quite so strong in my favour, as there is not so large a disproportion in their weight.

" It is certain that a horse can exert his powers with greater ease and effect by himself than when incommoded by the diverse pulling of companions, and also that a sluggish animal must draw his own share. In turning, one horse is much more handy than a string; and no comparison can be made between the turning of a two and four-wheel carriage. I have never practised trotting.

" The question," concludes Mr. Hannam, " is not, as is frequently supposed, whether one horse single can draw more in proportion than any number harnessed together, which I believe is generally admitted; it is not altogether which will move the greatest weight; but the question is, which will transport in the most ready and economical manner the materials required to be passed between the field and the homestead, or between one field and another. For in the carrying operations of a farm, with the exception of drawing corn to market, a certain bulk has to be transferred from one point to another, not by one effort, but by a continuous succession of them. Practically speaking, the loading and unloading have to be kept in constant activity by a chain of carriages passing between them. What, then, is the best and most economical intermediate conveyance is not an easy matter for consideration. The best implement and best moving power have to be ascertained; and, among known methods, the selection ranges widely between the barrow or pack-saddle and the eight-horse waggon. Our present consideration, however, is whether one-horse carts are more ready and economical for the purpose than the methods now generally in use."

The *outlay of capital* is certainly in favour of the substitution of carts for waggons. Mr. Bowly, of Siddington, has given the following com-

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band tolerably slack, and that the horse drew the load up this steep point (1 in 7) without difficulty; and he thought he might have managed a ton. "The horse, however, had a *knack of thwarting the road*," a method of easing the ascent horses are very ready at in the north: in a waggon they cannot do it. His opinion also was, that four horses, with two tons on a waggon, would have very tight work at this part of the hill.

parative calculation of the outlay required by the two systems, on 50 acres of arable land (*Jour. R. A. S.* vol. vi. p. 156):—

	£		£
1 Waggon	25	2 4-inch wheel one-horse carts	24
1 Dung cart	15		
3 Horses	60	2 Horses	40
Extra harness	2		——
Proportionate cost of light cart to 50 acres	3		64
		Balance in favour of carts .	41
	——		——
	105		105

"In conclusion," says Mr. Bowly, "I may remark that the principle of one-horse carts is quickness of motion; therefore they must be loaded according to the land to be passed over, so as not to reduce the pace of travelling; and I can assure those who are timid about them, that they are much less liable to accidents of every kind than waggons, and that however prejudiced the workman may be against their first introduction, when he becomes acquainted with the system he will prefer it.

"The description of carts I make use of are, five common Scotch carts and one skeleton cart; those of the former, with narrow wheels, cost me 10 guineas each; and with the 4-inch wheels (which I recommend) 12*l.*, with harvest-frame, &c. complete. The skeleton with narrow wheels cost me 10*l.*; it will carry more hay or straw than the others, its loads being in proportion of four carts to three waggons; it is more convenient for conveying poles, hurdles, &c.; and one on a farm may be useful, but it will not answer in dung-carting, and its advantages in harvesting are not sufficient to remunerate for the additional outlay of a double set."

The one-horse carts, then, we perceive, have been successfully tried, and preferred to waggons in the northern counties and in Oxfordshire. We have equally satisfactory evidence of their employment on the stiff clays of Gloucestershire and the Weald of Kent, and the deep soils of Huntingdonshire. "My land," observes Mr. T. Baker, of Hardwicke Court, near Gloucester, (*Jour. R. A. S.* vol. i. p. 429,) "is a stiff clay; my carts are on six-inch wheels, and made to hold half the quantity that my neighbours carry in theirs. My land is hilly: my carts generally go with one horse; but up hill, when loaded, another is put on before, which comes down the hill with the next returning cart. Thus, on level ground, with two carts, and two, or perhaps with three horses, I take out the same quantity of dung that my neighbours carry in their large carts with never less than three horses, and often with four. All my carts have reins; a boy walks and drives them when loaded, but when returning empty he gets into the cart and trots back at the rate of about five miles an hour, which of course saves about half the time in returning. Here again I have a manifest advantage in using lighter and more active horses.

"Some time ago I made the following trial. Two heaps of stone, of 32 tons each, were landed from a barge: they were to be taken to the same place, about a mile and a quarter off. A farmer began the first with two large carts and three horses; one cart was being loaded while the other was moving, and the horses were taken off and put on at every load. Finding that he could not do it in the day, he gave over at the

end of about six hours, and set to again the next morning, this rest, of course, giving him an advantage, as you will see; but, anxious for their own credit, both he and his man made the very best use of their time. Their work was completed at eleven loads, (which of course is nearly three tons to each load, or one ton to each horse,) in nine hours and fifty minutes. I began the other heap with three small one-horse carts, and completed it in one day, at twenty-one loads, (being nearly a ton and a half to each horse,) in six hours and one minute; which was a saving of about three hours and a quarter on nine hours and fifty minutes, or rather more than one-third. In this I had three decided advantages—first, the saving of time by trotting back; secondly, the rest that each of my horses got in his turn while his cart was being loaded; and thirdly, the ease with which my carts were loaded in consequence of being lower."

"Having," remarks Mr. Jesse French, of Rolvenden, (*ibid.* vol. vi. p. 377,) "pursued this plan of carrying corn and hay for two years, and one of my neighbours having followed my example last year, I draw the following conclusions from the observations I have made: that in carrying *bound* corn, the one-horse cart system has several advantages over that of waggons; and in carrying *loose* corn or hay, though the loader and he who throws it off may complain, and strong prejudices, the effect of habit, may possess the minds of all the hands employed, there is, upon the whole, no disadvantage. Three carts will generally be sufficient where the distance does not exceed half a mile, for one cart to be always loading; and for every additional half mile, one additional cart will be about sufficient; but this will depend in a great measure upon the road." It is true, as he very justly adds, that "there certainly are various things which a farmer may have to carry, for which one-horse carts are not adapted, as timber and hop-poles, which in Kent and Sussex are often carried a long distance. In the same district many farmers bring their hay from the marshes, a distance of from three to eight miles. For this purpose small carts are not so convenient; but for carrying hay, and particularly where it has to be carried a considerable distance, a small cart may be enlarged by this expedient. The draught staples being generally about a foot from the ends of the shafts, by attaching rings to their extreme ends for the horse to draw by, the wheels will be thrown a foot further behind the horse; consequently the fore-ladder may be fixed a foot forwarder on the shafts. This will allow for the tail-ladder to lean further back, so as the load may balance. By thus lengthening the load, and keeping it a good width, as much hay may be loaded as a horse will be well able to draw."

"And it will be seen," remarks Mr. E. Loomes, of Whittlesea, near Peterborough, (*ibid.* p. 398,) from the following table, (which I have laid down from a careful observation of the capabilities of one-horse carts and waggons,) that one horse in a cart is capable of conveying much more than half what can be carried on a waggon with two horses."

ONE-HORSE CARTS.		TWO-HORSE WAGGONS.	
Wheat-sheaves . .	172	Wheat-sheaves . .	207
Corn, Cake, &c. .	25 cwt.	Corn, Cake, &c. . .	45 cwt.
Bones	60 bush.	Bones	100 bush.

In dung carting, under ordinary circumstances, *one*-horse carts appear to have, in ordinary circumstances, a decided advantage. Mr. Love has given the following comparative table of the economy of both *one* and *two*-horse carts, (*Jour. R. A. S.* vol. vii. p. 225,) in the different distances

supposed to be travelled; and each boy driving is counted as the fourth of a man tipping; a man's wages is reckoned as 2*s*. per day, and the expense of each horse 3*s*. per day of nine hours.

	One-horse carts.	Two-horse carts.	One-horse carts.	Two-horse carts.	One-horse carts.	Two-horse carts.
Distance in furlongs	3	3	3	3	7	7
Time of travelling a revolution	15	15	15	15	35	35
Number of horses	3	3	5	5	9	9
Number of carts	3	2	5	3	9	5
Men filling the carts	2	2	4	4	4	4
Time of filling	10	15	5	7½	5	7½
Men tipping and driving	1¼	1	1¾	1¼	2¾	1¾
Time of tipping	5	7½	5	7½	5	7½
Total time to each revolution	30	37½	25	30	45	50
Number of loads drawn	54	29	108	54	108	54
Number of yards drawn	54	43½	108	81	108	81
	s. *d*.	*s*. *d*.	*s*. *d*.	*s*. *d*.	*s*. *d*.	*s*. *d*.
Expense of horses	9 0	9 0	15 0	15 0	27 0	27 0
Expense of men	6 6	6 0	11 6	10 6	13 6	11 6
Total day's expenses	15 6	15 0	26 6	25 6	40 6	38 6
Expense of carting thirty yards	8 7½	10 2¾	7 4¼	9 5	11 3	14 3
Saving by one-horse carts per acre	1 7½	...	2 0¾	...	3 0	...

Mr. John Dryden has described (*Trans. High. Soc.* vol. ix. p. 344) a plan for an improvement in single-horse carts, by which the evils of a fixed balance of the load in a cart are avoided; and a very useful sketch of a Welsh drag is given in a subsequent page, (*ibid.* p. 344,) whose use would, I think, in hilly countries, materially facilitate the general employment of one-horse carts.

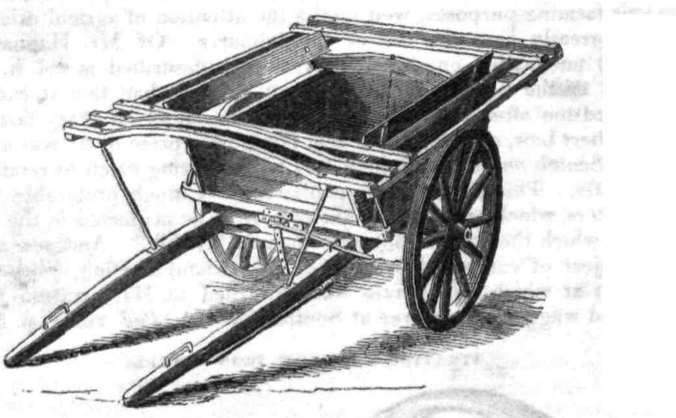
"That the state of the road has a very material influence upon the animal power required to draw a given weight over it every person is well aware, but few persons regard the difference between the labour of drawing a carriage over a road in good condition and the same road when out of order. This has been, however, experimentally determined, and we commend to every farmer and every overseer the careful and steady consideration of the results thus obtained. In these trials it was found that a light carriage with four wheels, weighing with its load 1000 lbs., required a force of traction as follows" (*Farmer's Almanack*, vol. i. p. 61):—

On a turnpike road, when hard and dry	30½	lbs.
On the same road, when dirty	39	,,
On a hard compact loam	53	,,
On an ordinary bye-road	106	,,
On a turnpike road newly gravelled	143	,,
On a loose sandy road	204	,,

The care with which all drivers avoid the newly gravelled portions of a road is well known, yet few of even the best whips, I think, are aware of the enormous difference of pressure upon the collar shown by the above table to exist, when the load is passing over a hard and dry turnpike road, and the same road when newly gravelled, composed of loose sandy materials. The farmers' club, then, we cannot but feel, arrived at a tolerably correct conclusion when they thus gave the preference to

one-horse carts for the general purposes of the farm. The farmer, however, who resolves to make trial of these advantages, must be firm and resolute, for, like every other alteration, it will hardly fail otherwise of being met by a strong opposition from his servants. To this end a hint or two of Mr. Hannam's will be useful; he observes, "I market my corn, according to the northern practice, in the dung-cart; it is not so convenient to unload sacks from as a waggon, but the load it carries, viz., 5 qrs. of wheat, 6 qrs. of barley, and other grain in proportion, and in back carriage half a waggon-load of ashes, compensates for small inconveniences. The only objection that I have heard the carters make to the system in thus carrying out the corn is, that they find themselves singular, and making but a bad figure by the side of a waggon and team of horses. They should therefore be indulged with a reserve of the best carts, kept well painted, and washed after being used for manures, and with harness a little ornamented."

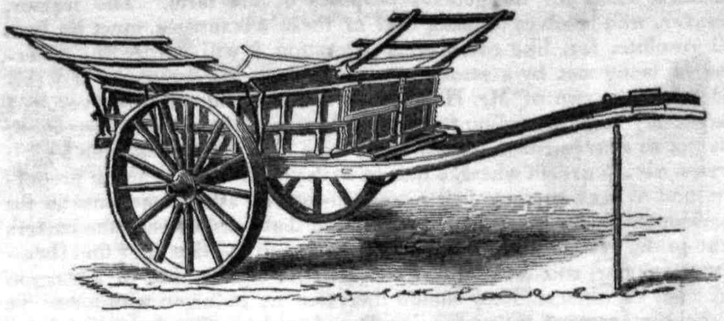
Of the many excellent carts prepared by various makers, I will only allude to two, those of Mr. Crosskill of Beverley, and of Messrs. Stratton of Bristol.



The One-Horse Cart of Crosskill of Beverley.]

"Mr. Crosskill's," said the judges of the Shrewsbury meeting, (*Jour.* vol. vi. p. 321,) "is a thoroughly well made and cheap one-horse cart, having a particularly simple and safe tipping contrivance. The especial reason for awarding to it a premium of 2*l.* was the introduction of a self-acting tail-board, which opens and shuts as the body is tipped, or brought home, so that no time is lost by having to unship and ship a tail-board, whether the contents of the cart have to be discharged at once or at intervals." At the Newcastle meeting it obtained the prize of 5*l.* (*ibid.* vol. vii. p. 684).

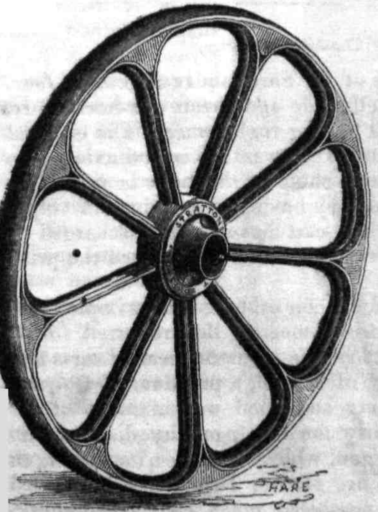
Of the cart of Messrs. Stratton, and of their other excellent implements of a similar kind, the judges of the Bristol meeting thus reported, (*Jour.* vol. iii. p. 349,) "The show-yard was rich in an assortment of carts and waggons. To Mr. Richard Stratton, of Bristol, a premium of 10*l.* was assigned for the extraordinary variety and good workmanship of his immense collection; more particularly for the ingenuity displayed in the construction of a cross-lock waggon, which facilitates its turning in a very small space, and permits the use of four large wheels of equal diameter. A tipping waggon also possessed much mechanical merit, but it is to be recommended as better adapted to commercial than to



[*The Cart of Messrs. Stratton and Co. of Bristol.*]

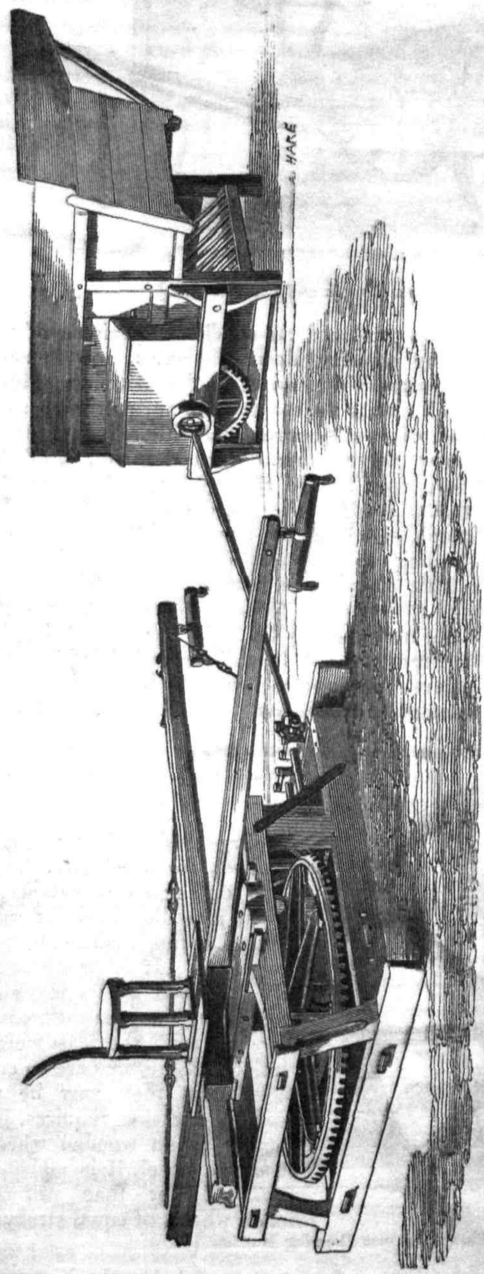
agricultural use. Mr. Stratton produced an excellent specimen of the low-chested cart, obtained by cranking down the axles, now in such general use by mercantile men and shippers. This disposition, modified to suit farming purposes, well merits the attention of agriculturists, as it would greatly ease the toil of the labourer. Of Mr. Hannam's (of Burcot) unequalled one-horse harvest-cart, described in vol. ii. of the Journal of the Society, more need not be said than that it cannot be exhibited too often, and that it ought to be found on every farm. To Mr. Robert Law, of Shettleston, near Glasgow, a prize of 3*l.* was awarded for his Scotch one-horse tipping-cart with a spring catch to retain it on the shafts. This simple little contrivance is much preferable to pins and cotters, which are apt to shake out, or to be neglected in the fastening, by which the load is not unfrequently let fall." And see also, on the subject of carting, the report of the Bristol meeting, (*ibid.* vol. iv. p. 492,) at which two prizes were awarded to Mr. Stratton for his carts and waggons, and three at Southampton. (*Ibid.* vol. v. p. 365.)

STRATTON'S HOLLOW IRON WHEEL.



An improved hollow wrought iron wheel, for which Mr. Stratton has obtained a patent, seems the best metallic wheel for carts and waggons that has been hitherto produced. It is pretty accurately described by its inventor, as combining the greatest amount of strength with the least weight of iron; and the tires are so constructed that they may be replaced, as occasion requires, just as easily as on wooden wheels. The entire wheel, it is added, is actually lighter than ordinary wooden wheels of equal strength.

THRASHING MACHINES.

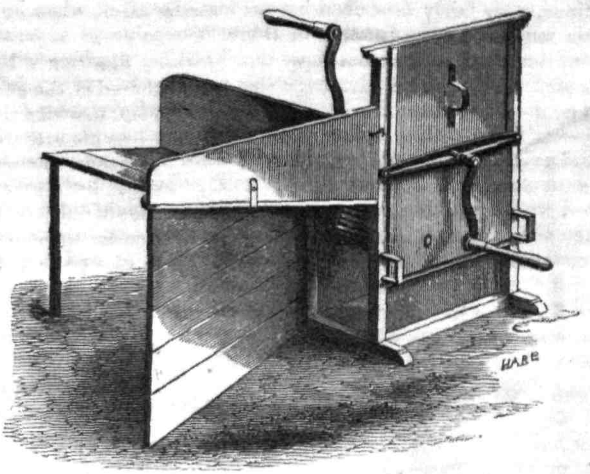


[*Ransome's Four-Horse Portable Thrashing Machine, as fixed for Work.*]

600

The corn being gathered in, the next implement to which the farmer turns his attention is the thrashing machine: of these I will give engravings of only two varieties, one for those worked by horse power, and one by hand power. (See "*Thrashing Machines,*" *British Husbandry,* vol. ii. p. 198.)

In the judges' report upon the implements exhibited at the Royal Agricultural Society's meeting at Oxford, in 1839, when speaking of that by Messrs. Ransome, they "commended this machine for the general good workmanship displayed in it, and the *proper proportion of its parts,* both as to durability and getting up the required speed:" they stated, "it was also particularly deserving of attention, from the application of the correctly shaped toothed wheels." (*Jour. R. A. S. E.* v. i. p. lxviii.) At the Society's meeting at Cambridge, in 1840, this machine was exhibited, and thrashed out sixty-one bushels and three pecks of wheat, with four horses, in one hour; and performed the work to the entire satisfaction of the owner of the corn. At the meeting at Bristol, in 1842, the thrashing part of this machine was exhibited, in connection with a portable steam engine, and obtained the Society's highest prize of 30*l.* (*Jour.* v. iii. p. 351.)

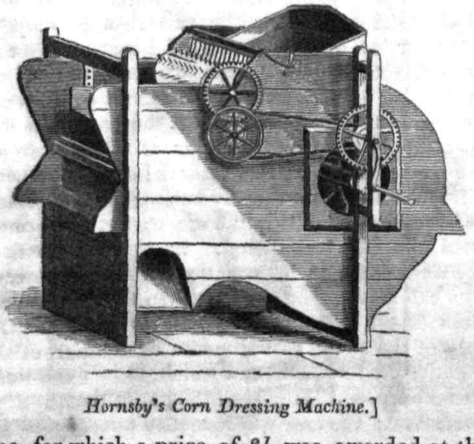


[*The Hand Thrashing Machine of Barett, Exall, and Andrewes.*]

This excellent machine, to which prizes have been awarded by the Societies of Dublin, in April 1845, Gloucester, in November 1843, Yorkshire, in August 1844, and in August 1845, is, I believe, correctly described by its very honourable manufacturers, when they remark, "They are as portable as a common winnowing fan, are easily carried by two lads, occupy a very small space, and are fitted in every respect in the best manner, and with the best material. They will thrash any variety of grain without injury, and do not break the straw *so much* as when thrashed by the flail."

WINNOWING MACHINE.

From the thrashing machine, the corn is transferred to one of another lescription, to be cleansed from the chaff, &c. Of the many excellent vinnowing machines, I have space but for one engraving.



Hornsby's Corn Dressing Machine.]

This machine, for which a prize of *3l.* was awarded at the Newcastle eeting of the Royal English Agricultural Society, (*Jour.* v. vii. p. 685,)

is, I believe, very fairly described by the manufacturer, when he says of it, " This improved corn dressing machine is capable of separating the corn from the chaff as it comes from the thrashing machine without the use of a jack riddle. The advantage this machine has over others when separating the corn from the chaff in a rough pulsy state, not riddled, is, its being fitted with a spike roller working through a grating, the roller and grating being so arranged as to form a hopper; and it can be adjusted to suit corn either in rough chaff or in any other state. It is also fitted with a shaking screen at the bottom, which more effectually cleans the corn from all kinds of small seeds than a fixed screen." (See "*Winnowing Machines*," *British Husbandry*, v. i. p. 7; and v. ii. p. 201.)

SECTION VII.

THE FERTILIZING OF THE SOIL*.

MANURES.

The advances which have been made, during the last few years, in the knowledge of the properties and economy of manures, have been perhaps more considerable than in any other branch of agriculture. For this very extensive and profitable march, the farmer is mainly indebted to the elaborate researches of the chemist, whose " magic" experiments have, with increasing rapidity, succeeded in presenting to the farmer, on this important head, much that is curious, much that is instructive, and an equally considerable proportion that is profitable to him in his difficult avocations. It has been shown, amongst other important facts, that the ideas entertained by the farmers of a bygone generation, with regard to the mode in which a fertilizer increases the growth of a plant, were generally incorrect, and not seldom worse than useless, as leading to the adoption of unmeaning attempts, and false principles of action. That the food consumed by an animal furnishes all the ingredients of which that animal is composed, is a self-evident conclusion, to which the learned physician, very readily, and at a very early period arrived. He could not, for instance, attribute the origin of the bones of animals to any other source than to either the animal and vegetable matters on which they fed, or to the phosphate of lime contained in our daily bread; he found, too, that in certain diseases, this salt being ill supplied to the growing animal, its bones become soft; his reason, therefore, soon suggested to him a ready cure: he gave, and with success, to such patients a supply of either the flour of bone, or ivory dust, or of some other substance in which this essential salt of bones abounds; and this he did, because he found that by such treatment the patient assimilated a larger proportion of this " bone earth;" the bones, therefore, were hardened, the cure completed. In the same way it was noted, when poultry were confined in situations where they could not obtain free access to calcareous matters, that then they laid their eggs without shells. It was found by every housewife to be a ready cure, to give them a supply of the chalk, or carbonate of lime, of which these shells are almost entirely composed, and which it is evident they could not *generate* for the purpose. All these things, in the case of animals, was very soon perceived; the case was reasoned upon, the deficient salt suc-

* *Supplementary Note, No. 9, for vol. i. p. 222.*

cessfully supplied. But it was much longer before this chain of reasoning was applied to the wants of cultivated plants, and the deficiencies of the soil on which those cultivated crops of the farmer grew. To *them* a different kind of reasoning was directed. It was fancied that plants *generated*, as it were, their own ingredients, that is, formed by some unknown process all their earthy and saline ingredients out of the air which surrounded, or the water which nourished them; and although it was in a very early period seen that plants contained a considerable portion of these earthy and saline matters, yet few useful attempts were made to prove to the farmer, that these ingredients being only furnished by the soil to the plant, in consequence those soils which could not yield them were the "poor soils" of the farmer, and those which could copiously supply them were the "rich soils." Rather than arrive at this practically useful reasoning, all kinds of erroneous or unmeaning reasoning were employed. It was said, for instance, that the inferior soils were "too hot" or "too cold;" that the application of manure "cooled" the first, and "warmed" the last. No one deemed it more rational to acknowledge, that as the animal procured all the ingredients of which *its* substance was composed from the vegetables which formed its food, so these plants must in their turn procure their food, that is, earthy or saline ingredients, from the soil on which they grew; and that, when these materials were exhausted by successive crops, then the ground would thus become less productive, or barren. Rather than adopt this very useful reasoning, all kinds of mere verbiage were employed. It was said that the ground was "tired," that it wanted "rest;" and when it was accidentally found out that the use of crushed bones was a powerful manure for turnips on the light soils of England; and further, when it was proved by the chemist that these were composed of one half of their weight of phosphate of lime, and that this was an essential and abounding ingredient in the turnip plant, still, few persons attributed the fertilizing properties of the bones to the phosphate of lime. It was to "the grease" of the bones that almost every one attributed their great fertilizing powers. It was allowed, however, by the great Lincolnshire farmers, who soon extensively used this valuable manure, that the bone-dressed turnips were rather more nourishing than those produced in the ordinary way. The chemist demonstrated that they contained *more* phosphate of lime, as may be seen from the results of the following analysis of the ashes of 100 parts of some Swedish turnips grown in the ordinary way, and manured with guano, a substance in which, like bones, the phosphate of lime forms the chief fixed ingredient. (*Farmer's Almanack*, vol. ii. p. 243.)

	Dunged.	Guanoed.
Chloride of potassium	9·72	6·45
Potash and soda	45·49	36·29
Magnesia	1·23	0·39
Lime	10·17	11·56
Sulphuric acid	17·86	16·86
Phosphoric acid	7·73	19·39

And finally it was suggested, that if the phosphate of lime could be rendered by any process more soluble, that is, capable of being more easily and rapidly absorbed by the plant, then the power of this salt, if it really does form the chief fertilizing ingredient of the bones, ought to be rendered more rapid. Now this is the very result which the successful modern process of previously mixing sulphuric acid with the

bones accomplishes; the super-phosphate of lime, which is thus produced, being soluble in water, which the phosphate of lime of the bones is not. I have, in these observations, confined my attention to one salt, common both to animal and vegetable substances, and the sources whence they obtain it; but the same remarks apply to the carbonate of lime, the soda, the nitrogen, and to almost all the other constituents of the two great classes of organized beings. It is, in such cases, a mere transfer of the ingredient from the soil to the plant; from the vegetable to the animal; and by both back again to the soil; and, in any case, if this return is even only partially less in amount, that soil must become less fertile, and in no way can its original productiveness be restored, but by restoring to it, in some form or other, the very chemical substances which the crops of the farmer have withdrawn, and his growing live stock carried off the land. "The earthy part of the soil is not," remarks Professor J. F. Johnston, (*Elements of Chemistry*, p. 39,) "as some have supposed, a mere substratum, in which the plant may so root itself as to be able to maintain its upright position against the force of winds and tempests, but it is a storehouse of food also, from which the roots of the plant may select such earthy substances as are *necessary or fitted to promote its growth*." And the young farmer, when he is endeavouring to understand the true theory of the food of plants, and the operation of fertilizers, must discard from his mind all suspicion that these earthy and saline substances, found in the substance of his crops, are merely there by accident, or absorbed by their roots accidentally in the moisture of the soil; for, on the contrary, it has been shown that these substances are always found in the plant, and that they vary in amount at different stages of its growth. Thus, to give a single instance, Mr. J. P. Norton, (*Trans. High. Soc.* 1845, p. 321; *Farmer's Almanack*, vol. iii. p. 19,) has shown that the ashes of the stalk of the unripe potato-oat contained

	June 4.	June 18.	July 2.	July 16.
Potash and soda	24·94	26·49	36·25	42·43
Common salt	32·66	24·94	11·62	4·46
Lime	2·40	3·74	2·64	4·12
Magnesia	0·88	2·20	1·17	1·47
Oxide of iron	0·39	0·40	0·88	0·62
Sulphuric acid	6·15	8·51	7·98	7·84
Phosphoric acid	16·15	12·55	2·21	6·31
Silica	16·29	20·41	36·64	34·85

It is true that the *amount* of these fixed or inorganic substances varies in the same species of plant grown on different soils; but, although the *proportions* vary, the *ingredients* do not alter; and so closely is the *proportion* preserved in which they exist, that Professor Johnston has been able to determine pretty accurately the general amount of the inorganic ingredients carried off the soil, per acre, by the ordinary rotation of the four-course system. As the basis of this calculation, he supposes the turnips to consist of 25 tons of bulbs, and 7 tons of tops; the barley, of 38 bushels of 63 lbs. each, and 1 ton of straw; the clover and rye-grass, of 1 ton of each in hay; and the wheat crop to be composed of 25 bushels of 60 lbs., and 1¾ tons of straw. These, he calculates, (*Elements of Chemistry*, p. 51,) will contain and carry away from the soil, (supposing none of them to be eaten on the land,)—

Potash	280 lbs.	Sulphuric acid . .	111 lbs.
Soda	150 „	Phosphoric acid . .	90 „
Lime	242 „	Chlorine	39 „
Magnesia	50 „		——
Silica	318 „	Total . . .	1280 lbs.

So that, if we carry off the entire produce, and add none of it again in the shape of manure, we ought every fourth year to add to the soil per acre, if we wish to restore it to its original condition, (*ibid*, p. 52,)

Pearl or potash	390 lbs. at a cost of	£3	10	0
Crystallized carbonate of soda .	500 „ . . „	2	12	0
Common salt	65 „ „	0	2	0
Gypsum	60 „ „	0	1	6
Lime	160 „ „	0	0	8
Epsom salts (sulphate of magnesia)	250 „ „	1	5	0
Bone-dust	360 „ „	1	2	0
Total . . .	1785	£8	13	2

We may safely, then, adopt the conclusion of Liebig, when he tells us (*Organic Chemistry*, p. 93) that " many of these inorganic constituents vary according to the soil in which the plants grow, but a certain number of them are indispensable to their development. All substances in solution in a soil are absorbed by the roots of plants, exactly as a sponge imbibes a liquid, and all that it contains, without selection. The substances thus conveyed to plants are retained in greater or less quantity, or are entirely separated when not suited for assimilation."

The results of these chemical researches it will be found very serviceable to bear in mind, in the investigation of the composition and uses of all fertilizers. (See " *British Husbandry*," vol. i. pp. 222–436.) In the following sketch of the uses of various manures, it will perhaps tend to a better understanding of the subject, if we commence with those of an earthy or more permanent nature, before we proceed to those of an organic, or decomposing, or saline class.

EARTHY MANURES AND SOILS *.

The chief cultivated soils with which the farmer has to contend, although in reality mixtures of sand, clay, and chalk with various saline and organic matters, may, for the convenience of something like a classification, be arranged under the heads of sand, clay, and chalk. These, it must be remembered, are fertile according to the proportions in which they are united together; and, as a general rule, it may be taken that, whenever any one of these earths is deficient in a soil, the addition of such earth will add to its fertility; and hence they all, in some situation or other, are found to be useful additions or fertilizers to soils in which the added earth naturally exists in insufficient proportions. Before we proceed to trace the chief modern experiments which have been instituted to promote the use of earthy or permanent manures, it will be of advantage to examine a few of the physical properties of the earths commonly employed by the cultivator as fertilizing additions, most of which have been usefully illustrated in the laborious experiments of M. Schubler, translated and published by Mr. Hudson. (*Jour. R. A. S.* vol. i. p. 177.) The weight of these earths differs very materially, according to its degree of dryness. In the following tables, the *wet* state

* See " *British Husbandry*," *vol.* i. *p.* 434.

is regarded as being that when a soil thoroughly moistened is laid in a wet state on a filter, and no longer allows any water to drop through.

Several of the earths exhibited the following differences in reference to this point:—

Kinds of Earth.	Specific Gravity, that of Water being taken as = 1.	Weight of a Cubic Foot. In the dry state.	Weight of a Cubic Foot. In the wet state.
		Pounds.	Pounds.
Calcareous sand	2.722	113.6	141.3
Siliceous sand	2.653	111.3	136.1
Gypsum powder	2.331	91.9	127.6
Sandy clay	2.601	97.8	129.7
Loamy clay	2.581	88.5	124.1
Stiff clay, or brick earth	2.560	80.3	119.6
Pure grey clay	2.533	75.2	115.8
Fine white clay (pipe clay)	2.440	47.9	102.1
Fine carbonate of lime	2.468	53.7	103.5
Fine carbonate of magnesia	2.194	15.8	76.3
Humus	1.370	34.8	81.7
Garden mould	2.332	68.7	102.7
Arable soil	2.401	84.5	119.1
Fine slaty marl	2.631	112.0	140.8

Weight of Artificial Mixtures of Earths.—When different earths are artificially mixed together, a cubic inch of the earthy mixture obtained gives a weight greater than the arithmetical mean (or common average) of the earths entering into the mixture, whether mixed in equal portions according to weight or volume, or in other quantities. "I took," says M. Schubler, "in different proportions, a common siliceous sand, a rich clay, and a fine clay-marl, of which I had previously ascertained the absolute weights, and mixed them together, when I determined the weight of the mixture and obtained the following results:—

Kinds of Earth.	Weight of 5.7 Cubic Inches.	Arithmetical Mean.	Increase of Weight.
	Grains.	Grains.	Grains.
Common siliceous sand	2840		
Stiff clay, or brick earth	2020		
Fine clay-marl	1790		
Clay and sand in equal proportions by weight	2545	2430	115
Clay and sand in equal proportions by volume	2685	2430	255
2 parts clay and 1 part sand by weight	2390	2293	97
2 parts clay and 1 part sand by volume	2470	2293	177
2 parts sand and 1 part clay by weight	2740	2566	174
2 parts sand and 1 part clay by volume	2825	2566	259
Equal parts of marl and sand by weight	2315	2267	48

"This phenomenon is only to be explained by supposing a more intimate approach in the interstices of the contiguous earthy particles; something similar, therefore, seems here to happen with this mechanical commixture to what takes place in a still higher degree with natural mixtures of earthy and rocky materials, for instance, with the dolomite

sand and stony marls, in which cases not only the absolute weight, but the real specific gravity also, is greater than in the separate earths."*

A very important question to the farmer is the amount of water, both by weight and volume, which various soils are capable of containing: this we shall find determined in the following table. To obtain these results considerable care is required.

It might appear, that this determination could be made by the mere comparison of the weights of a cubic inch of dry and wet soil, or from the absolute weight of a volume of the dry soil, and its power of containing water; we should, however, in this way obtain no correct result, because many soils, especially those containing clay and humus abundantly, contract considerably in drying, a cubic inch of such dry soils generally occupying a greater space in their wet state.

Kinds of Earth.	Power of containing water.		A cubic foot of the wet earth contains of water
	According to weight.	According to volume.	
	Per cent.	Per cent.	Pounds.
Siliceous sand	25	37.9	27.3
Calcareous sand	29	44.1	31.8
Gypsum powder	27	38.2	27.4
Lime, precipitated	47	54.5	39.1
Fine lime	85	66.1	47.5
Fine magnesia	256	76.1	62.6
Sandy clay	40	51.4	38.8
Loamy clay	50	57.3	41.4
Stiff clay, or brick earth	61	62.9	45.4
Pure grey clay	70	66.2	48.3
White clay, pipe-clay	87	66.0	47.4
Humus	181	69.8	50.1
Garden mould	89	67.3	48.4
Arable soil	52	57.3	40.8
Slaty marl	34	49.9	35.6

The rapidity with which the water contained in various soils evaporates, by exposure to the atmosphere, varies very considerably. The following table contains the results of the experiments made by M. Schubler, in reference to this point, with 200 grains of the several earths at a temperature of $65\frac{3}{4}°$: they were spread out over a surface of ten square inches. The second column of the table contains in one view the portions of time in which the several earths respectively became dry under exposure to the same temperature; he did not require a perfect state of dryness, as this, at a temperature of $65\frac{3}{4}°$ F. and in the open air, could not be expected.

* Such researches as these all tend to promote the *permanent* improvement of the soil by the admixture of earths; and there is no doubt of the great advantage of this mode of improving land. "The best natural soils," said Davy, "are those of which the materials have been derived from different strata; which have been minutely divided by air and water, and are intimately blended together; and in improving soils artificially, the farmer cannot do better than imitate the processes of nature. The materials necessary for the purpose are seldom far distant, coarse sand is often found immediately on chalk, and beds of sand and gravel are common below clay; the labour of improving the texture or constitution of the soil is repaid by a great permanent advantage; less manure is required, and its fertility insured; and capital laid out in this way secures for ever the productiveness, and, consequently, the value of the land."—(*Elem. Agric. Chem.* p. 204.)

Kinds of Earth.	Capability of drying. Evaporation from 100 parts of absorbed water, at 65¾° F. in 4 hours.	Times required for 90 parts of water to evaporate (at 65¾° F.) from 100 parts absorbed.	
	Parts.	Hours.	Minutes.
Siliceous sand	88.4	4	4
Calcareous sand	75.9	4	44
Gypsum powder	71.7	5	1
Sandy clay	52.0	6	55
Loamy clay	45.7	7	52
Stiff clay, or brick earth	34.9	10	19
Pure grey clay	31.9	11	17
Fine lime	28.0	12	51
Humus	20.5	17	33
Magnesia	10.8	33	20
Garden mould	24.3	14	49
Arable soil	32.0	11	15
Slaty marl	68.0	5	53

The degree of *contraction* which soils undergo, by being dried, also varies very considerably. The subjoined table gives the extent of this in the cases of the common earths.

Kinds of Earth.	1000 cubic lines became diminished in volume to	1000 parts therefore diminished in volume by
Siliceous sand Calcareous sand	(no change)	...
Fine lime	950 cubic lines	50 parts.
Sandy clay	940 "	60 "
Loamy clay	911 "	89 "
Stiff clay, or brick earth	886 "	114 "
Pure grey clay	817 "	183 "
Carbonate of magnesia	846 "	154 "
Humus	800 "	200 "
Garden mould	851 "	149 "
Arable soil	880 "	120 "
Slaty marl	965 "	35 "

The extent to which various soils absorb the insensible vapour of the atmosphere was first endeavoured to be ascertained by Sir H. Davy (*Agric. Chem.* p. 183). It is a power, as he truly enough described it, much connected with fertility. M. Schubler has much extended the experiments of Davy. (*Jour. R. A. S.* vol. i. p. 196.) The following table gives the results of these valuable researches, which were made by exposing the various earths in an atmosphere contained in an inverted vessel, resting in a surface of water, in a temperature of 59° to 65¾°. Under these circumstances, the confined air, having free access to water, may be regarded as having been saturated with moisture.

Kinds of Earth.	1000 grains of Earth on a surface of 50 square inches, absorbed in—			
	12 Hours.	24 Hours.	48 Hours.	72 Hours.
	grains.	grains.	grains.	grains.
Siliceous sand . .	0	0	0	0
Calcareous sand . .	2	3	3	3
Gypsum powder . .	1	1	1	1
Sandy clay . . .	21	26	28	28
Loamy clay . . .	25	30	34	35
Stiff clay	30	36	40	41
Pure grey clay . .	37	42	48	49
Fine lime	26	31	35	35
Fine magnesia . .	69	76	80	82
Humus	80	97	110	120
Garden mould . .	35	45	50	52
Arable soil . . .	16	22	23	23
Slaty marl	24	29	32	33

The power of the earth to absorb oxygen gas from the atmosphere, a property highly conducive to the vegetation of plants, was first pointed out by M. Alexander Von Humboldt, (*Gilbert's Annals of Philosophy,* vol. i. p. 512,) the truth of whose observations was subsequently doubted by those chemists who afterwards repeated his trials, not being aware that, although *dry* earth *does not,* that moist earth possesses the power to a considerable and very beneficial extent. It will, perhaps, tend to the better understanding of the objects of those valuable examinations if, before I give the result of M. Schubler's experiments, I repeat what I have elsewhere remarked on the subject of the uses of oxygen gas to the growth of plants. (*Farmers' Encyclo.* p. 539.)

M. Saussure made many valuable researches upon the uses of oxygen gas to vegetation. He found that it was essential to many of its functions—that it was absorbed not only by the leaves, but by the roots of plants—that it then combined with carbon, and the carbonic acid gas thus formed was thence transmitted to the leaves to be decomposed: the very stems and branches of plants absorbed it, and its presence is essential to the expansion of flowers; in its absence, seeds will not germinate, and hence the reason why they will not vegetate when placed beyond a certain depth in the soil. The quantity of oxygen gas consumed during their germination, by equal weights of different seeds, varies considerably. Wheat and barley consume less oxygen than pease, and pease less than common broad and kidney beans, the latter consuming $\frac{1}{100}$th part of their weight, while wheat and barley, during their germination, only absorb from $\frac{1}{1000}$th to $\frac{1}{2000}$th their weight of oxygen gas. Recent experiments have shown, also, that the more water is impregnated with oxygen gas, the more excellent are its effects when employed for the purpose of watering plants; and hence one of the causes of the superiority of rain-water. Some recent experiments were made by Mr. Hill which clearly demonstrated these facts. Hyacinths, melons, Indian corn, and other plants, were watered for some time with water impregnated with oxygen gas; they first grew with increased beauty and luxuriance, the melons were improved in flavour, the Indian corn increased in size, so as "to equal in size most of those imported from North America," and all of them grew more vigorously.

The uses, therefore, of oxygen gas to plants are many and important, and accord with the conclusions which naturally suggest themselves from the results of the analysis of vegetable substances, from whence oxygen is never absent; it must be, therefore, one of the necessary supporters of vegetable life.

The following Table shows the extent of the absorption of oxygen gas by various earths, when in a moderately moistened state and in a temperature varying from 59° to $65\frac{3}{4}$°:—

Kinds of Earth.	Absorbed in the dry state.	In the wet state. Absorption in 30 days, by 1000 grains of Earth, from 15 Cubic Inches of Atmospheric Air containing 21 per cent. of Oxygen.		
		Per cent.	Cubic inches.	Grains.
Siliceous sand	0	1.6	0.24	0.10
Calcareous sand . . .	0	5.6	0.84	0.35
Gypsum powder . . .	0	2.7	0.40	0.17
Sandy clay	0	9.3	1.39	0.59
Loamy clay	0	11.0	1.65	0.70
Stiff clay, or brick earth	0	13.6	2.04	0.86
Pure grey clay . . .	0	15.3	2.29	0.97
Fine lime	0	10.8	1.62	0.69
Magnesia	0	17.0	2.66	1.08
Humus	0	20.3	3.04	1.29
Garden mould	0	18.0	2.60	1.10
Arable soil	0	16.2	2.43	1.03
Slaty marl	0	11.0	1.65	0.70

The warmth acquired by different soils from the sun, under the same circumstances, varies considerably in amount; and not only does this power of absorption vary in different soils, but the capacity for the *retention* of heat is as much diversified. Both these questions the young farmer will find answered in the following Tables of M. Schubler. The first contains, as he remarks, (*Jour. R. A. S.* vol. i. p. 204.) "the results of a series of experiments which I made on the different degrees in which earths acquire warmth from the sun in fine weather. I placed these earths in vessels of four square inches in surface and half an inch deep, and exposed them to the rays of the sun, coloured differently on the surface, and furnished with thermometers as already described; the observations were made in the latter part of August, and between 11 and 3 o'clock in the day, while the temperature of the air varied in the shade from $72\frac{1}{2}$° to 77° F. As all the observations could not be made at once, the temperature which sand acquired on the same occasion was in each case taken as the standard of comparison, to which all the several observations have been reduced.

Kinds of Earth.	Mean of Highest Temperature of the upper surfaces of the Earths. (77° F. in the shade.)			
	With a surface of the natural colour.		With dry earth.	
	Wet.	Dry.	With a white surface.	With a black surface.
	°	°	°	°
Siliceous sand, bright yellowish grey .	99.1	112.6	109.9	123.6
Calcareous sand, whitish grey . . .	99.3	112.1	109.9	124.0
Gypsum, bright white-grey	97.3	110.5	110.3	124.3
Sandy clay, yellowish	98.2	111.4	108.3	121.6
Loamy clay, yellowish	99.1	112.1	107.8	121.1

Kinds of Earth	Mean of Highest Temperature of the upper surfaces of the Earths. (77° F. in the shade.)			
	With a surface of the natural colour.		With dry earth.	
	Wet.	Dry.	With a white surface.	With a black surface.
	°	°	°	°
Stiff clay, or brick earth, yellowish grey	99.3	112.3	107.4	120.4
Fine bluish grey clay	99.5	113.0	106.3	120.0
Lime, white	96.1	109.4	109.2	122.9
Magnesia, pure white	95.2	108.7	108.7	121.3
Humus, brownish black	103.6	117.3	108.5	120.9
Garden mould, blackish grey . . .	99.5	113.5	108.3	122.5
Arable soil, grey	97.7	111.7	107.6	122.0
Slaty marl, brownish red	101.8	115.3	108.3	123.4

The next Table contains the results of trials made to determine the extent of the power possessed by different soils of giving out to surrounding bodies, in different lengths of time, the warmth communicated to them by the sun or the temperature of the atmosphere:—

Kinds of Earth.	Power of retaining Heat, that of Calcareous Sand being = 100.0	Length of time required by 30 Cubic Inches of Earth to cool down from a temperature of 144½° to 70¼° F. in a surrounding temperature of 61¼°.
Calcareous sand . . .	100.0	in 3 hours, 30 min.
Siliceous sand	95.6	3 — 20 —
Gypsum powder . . .	73.8	2 — 34 —
Sandy clay	76.9	2 — 41 —
Loamy clay	71.8	2 — 30 —
Stiff clay, or brick earth	68.4	2 — 24 —
Pure grey clay . . .	66.7	2 — 19 —
Fine lime	61.3	2 — 10 —
Humus	49.0	1 — 43 —
Fine magnesia	38.0	1 — 20 —
Garden mould	64.8	2 — 16 —
Arable soil	70.1	2 — 27 —
Slaty marl	98.1	3 — 26 —

SANDY SOILS *.

As I have had occasion to remark in another work, (*Bell's Messenger*, No. 2643,) the examination of poor soils—their management, and the means for their improvement—is always attended with benefit. Of the richer soils of England, indeed, we need evince much less solicitude; they are most commonly too valuable, too highly rented to have their cultivation neglected; they usually require more considerable capital in their holders than the poor sands and gravel of which I propose to speak in this essay. I intend, therefore, to gather up, on the behalf of the occupiers of this extensive class of farms, a few results of the valuable researches which have been recently made to advance their more profitable cultivation. These soils are dispersed in very considerable masses throughout England; they are the *diluvium* of the geologist. This, as the farmer well knows, is of varying composition. In Dorsetshire it is chiefly composed of a mixture of sand and gravelly flints. The largest portion of Suffolk and Norfolk is composed of a diluvium sand, of varying thickness, resting on chalk or marl. This district is very level: it extends from Sudbury to Bungay, and thence to Cromer;

* See "*British Husbandry*," *vol.* i. *pp.* 289, 319, 427.

from Southwold to Shelford; and from Swaffham to Yarmouth. In Kent, Berkshire, Hampshire, Sussex, Surrey, and other places, the rolled flints are mixed with a tenacious red clay. "Most of this soil," observes my excellent friend, Mr. Morton, in his valuable work on soils, "is in tolerable condition, and produces turnips, barley, oats, wheat, and clover; the tenacious clay gravel is expensive in the cultivation, as it is most difficult to work, except between wet and dry." It is not with this kind of diluvium, however, that I propose to treat: I intend to chiefly confine my observations to the light sands and gravels. Of these, as in all soils in fact, the *drainage* is the first consideration, before any other contemplated improvement can be carried into execution. It is here, however, that the owners of many light lands fall into the error of regarding under-draining as useless; they fancy, and very often erroneously, that "they are too dry" to need drains. I have seen, however, many soils, both in Essex and in Surrey, that were long considered by their occupiers to be free from land water, very materially improved in value by the construction of *deeply* laid tile drains; and I have witnessed these *constantly running*, even in the height of summer, from fields, where I felt it difficult (before test holes were made) to imagine the existence of a superabundance of water. The mode of draining these must of necessity be regulated by the circumstances in which the farmer is placed. For extreme cases, that of the drainage of running sands, the improver will find some very useful practical directions by Mr. W. Linton, (*Jour. R. A. S.* vol. vii. p. 118,) —directions too minute and extensive for these pages. He tell us, in conclusion, "of these running sands, I have drained about 500 acres, and when the plan which has been stated here at large was adopted, which has generally been the case, the average cost per acre was about *5l. 5s.*, that is to say, 1500 tiles, at *1l. 6s.* per 1000; 3000 bottoms, at 11*s.* per 1000; cutting, 1*l.* 10*s.*; and incidental expenses, 3*s.* I shall now" (he adds) "conclude these observations, by stating the result of these operations in draining, which indeed must be considered in conjunction with marling. The land in question was an inclosure of barren heath, and had been considered, and really was, previous to being drained and marled, worthless. It has now become profitable tillage land, and is advantageously cultivated under the four-course system. But to attempt such a work without carrying out the two great parts of agricultural improvement which these soils invariably require, namely, draining and marling, is, I think, superficial and unwise, and is always attended with disappointment and loss." Mr. Pusey (*ibid.* vol. iii. p. 180) has very clearly sketched the objects and expense of thus *permanently* improving poor light soils by tile drainage, and by earthy mixtures. After having stated the modes by which soils of a heavier kind are beneficially improved, he adds, "hitherto we have considered only one aspect of land, too great cohesiveness; there is an opposite fault, however, well known to farmers, too great looseness." This fault may be seen on tracts absolutely barren, as on Bagshot-heath, or on fields under culture which are termed blowing sands, because the surface sand drifts in high winds. In different degrees it is a common fault in land, and shows itself by thinness of the corn crop, and shortness of the straw and of the ear; formerly, indeed, rye was grown on such land instead of wheat. Folding with sheep, pressing, and shallow ploughing, diminish the evil, but do not remedy it. "The practice of our ancestors was (as Mr. Linton so well recommends) to cover such land with marl, which is usually a strong clay, containing a great deal of

lime." Marl was said, indeed, to benefit the land at first, but to injure it afterwards; to be "good for the father, but bad for the son." This injury, however, probably arose from improvidence. Marl was found to act without dung at first, and the fields which had been marled were consequently tilled without dung, until their soil was completely exhausted. It fell into disrepute, and many farmers are perhaps not aware that it is still used largely in England. "I doubt," observes Mr. Pusey, when speaking of the improvements made on the lands of Holkham, by the late Lord Leicester, "if that lamented nobleman, with all his enterprise, could have fed oxen where rabbits had previously browsed, as was his just boast, unless those sandy commons had been previously made solid with marl." The young farmer will find Mr. Overman, of Maulden, one of the extensive farmers of that noble estate, (made so valuable by the efforts of the great Coke,) describing his successful practice of marling, in one of the early volumes of the "Journal of the Royal English Agricultural Society," vol. iii. p. 233; he will there observe one or two errors that are to be avoided, and precautions adopted. After alluding to the nature of the farm, which consists of 630 acres of part gravel, part sand, part moorland covered with rushes, and some strong clay land, he says, going at once like an English farmer to the practical working of the system, "Upon the gravel and sand land I put 40 loads (of 40 bushels) per acre; on the moorlands, 70 loads. I give my men *3d.* per load to cart and fill, and they earn from *2s. 3d.* to *2s. 6d.* per day. I have both marl and clay on my land, and always test them by vinegar. If they effervesce I consider them good: (this indicates the presence of carbonate of lime or chalk in the earth.) Land will not always show the benefit it derives from clay in the first crop, which is the reason that it is condemned by some persons; others dread the expense, which after all is but little. To sum up the benefits of clay to land in various ways, it is by correcting the acidity, and giving solidity, by stiffening the straw and increasing the quantity and quality of the corn, by preventing mildew, which this farm was always subject to, but which, since I have clayed, it has not been, by preventing the turnips from being diseased by graping, (fingers and toes,) and adding that to the soil which clover likes, more particularly the white or Dutch clover." On the Woburn Abbey Estate, in Bedfordshire, the employment of clay on the light soils has been nearly as extensive as on those of Holkham. Mr. Burness, of the Park Farm, at Woburn, when describing (*ibid.*) the system as practised in Bedfordshire, remarks, "we find the claying of our light soils of great advantage. It makes the straw much stronger, with a stronger ear, and standing much better up in wet seasons. My system has been to put the clay on the clover leys as early as the crop is off, and then to get it broken in pieces as much as possible before it is ploughed in for wheat —the quantity per acre is generally 50 loads. Nearly all the light soil on the farm of the Duke of Bedford at this place has been clayed, and a great deal of it twice, and in every instance we have found its beneficial effects. Draining, marling, claying, (and chalking in favourable localities,) are then the chief sources of *permanent* improvement to which the holders of the sandy and gravelly soils must chiefly direct their attention. The earths to which we have alluded may be generally obtained in some form or other in most districts; and, in those situations where the soil and the clay are *both* equally deficient in carbonate of lime, even this is not a bar to the improvement, for the proportion of this salt required by the largest crops commonly grown by the farmer

can be supplied by him to his land, in sufficient quantities, at a very inconsiderable expense in almost every locality. The proportion of lime required by the farmer's crops, as an effectual ingredient or food, is not so great as to make its carriage from even a considerable distance a material object. Thus, 100,000 lbs. (about 45 tons' weight) of the bulbs of turnips only absorb from the soil 127 lbs. of lime. (*Farmer's Almanack*, 1847, p. 63:—

100,000 lbs. of	Seeds of barley . . .	106 lbs.
"	Straw of barley . . .	554 "
"	Red clover	584 "
"	Seeds of wheat . . .	96 "
"	Straw of wheat . . .	240 "

So that the cultivator will see that a very moderate dressing of lime or chalk per acre will suffice to supply all the carbonate of lime needed by very large crops of his ordinary produce; and thus, while he derives, in case of need, all the advantages of increased solidity by the use of clay totally free from calcareous matters, the carbonate of lime (an invaluable ingredient in the best varieties of marl) can be readily and practically applied from other sources. This consideration, these facts, will, I am sure, not pass unheeded by many of my intelligent readers, who hold poor sandy and gravelly lands in the immediate neighbourhood of clay that, in common with the soil to which they propose to apply it, will *not* " effervesce with vinegar." I have, in this section, confined my attention to the chief modes of *permanently* improving these kinds of soil. Of the organic and saline manures the best adapted to their use, I may hereafter have occasion to speak, and in this respect light lands possess a very considerable advantage over the heavy clays, from the openness of their soils allowing the atmospheric air more ready access to all decomposing manures, such as bones, sprats, rape cake, &c. Their decomposition is thus very usefully accelerated, and the advantage derived from their use almost always much more manifest than upon the heavier classes of soils. We see, then, (and the conviction should act as a stimulant to our constantly renewed inquiries and efforts,) that even the poor sands and gravels may be not only permanently improved, but that they may also, from time to time, be enriched by the use of fertilizers peculiarly adapted for the purpose.

CLAY SOILS*.

The improvement of poor clay soils, although an effort of great importance, has not perhaps hitherto been attended with very general success. To this several causes have contributed. They are a description of soil rarely selected for cultivation by those great and enlightened agriculturists whose efforts have done so much for modern agriculture: from their nature, they are ill adapted, under the ordinary system of cultivation, for stock farms; their rotation does not readily include the necessary green crops; they are difficult to work; their lands, the farmer truly tells you, " can only be got upon" after dry weather; they are expensive to drain, and the roads by which they are approached are, generally speaking, the worst in our island; the holdings, often small, held by farmers of little capital, and the district possessing few attractions for the enterprising scientific capitalist. And yet there was a time when these were the lands an English farmer preferred to any other; but that was a period of England's agriculture when the value and

* See " *British Husbandry*," *vol.* i. *pp.* 426–439.

management of stock farms was ill understood, and when the clays had not then been so long and so gradually impoverished as at present. Mr. Milburn, the excellent secretary of the Yorkshire Agricultural Society, correctly describes the former state of things when he says, (*Farm. Mag.* vol. xxvi. p. 114,) "Before convertible husbandry was understood and acted upon, the clays were considered the most valuable soils. A good wheat and bean farm was what every farmer sought most anxiously after, while a light, sandy, or gravelly soil was disregarded. The grass land grew hay, which kept the stock in winter, and the pasture, on clays generally the best, fattened the cattle in summer for the market, while the tillage land grew wheat for sale, and beans and oats, partly for sale and partly to keep the heavy stocks of draught horses which were required to work the arable land. The great object of every farmer was to get permission from his landlord to plough up a grass field. This grew a succession of corn crops, produced much good straw for his stock, and a good deal of manure; and was, moreover, much more easily worked, and required less hand-weeding and ploughing; and it was many years before it got the dismal character of 'old going' land. Little was returned to the soil, and hence it underwent a process of deterioration every year. I was examined (continues Mr. Milburn) before a committee of the House of Commons on a railway bill last session, and, in giving evidence regarding a district through which it passed, stated that it was annually getting poorer and poorer. Its circumstances were these: it was entirely in grass: the best was mown every year, and little returned to it; the worst was depastured by poor breeding-stock, which were annually sold off; and thus nothing was kept upon it but what impoverished it, while there was nothing returned to the land. This was the Vale of Mallestang, in Westmoreland, the source of the river Eden, and this is what is daily taking place on the mass of tillage land farms."

It is of primary importance, then, that the occupier of such lands should fully comprehend the nature of this long-continued deteriorating process, for the correct knowledge of this leads, as a natural consequence, to the more rational modes of restoring that of which a long-neglected occupation has deprived the soil; and moreover points the way to the best system of perhaps materially increasing the original fertility of the land. In any of such proposed improvements it is of the first importance that the farmer should ascertain the nature of the subsoil on which the upper soil he cultivates rests. It is a common error to regard this as being always similar in its *earthy* composition to the surface soil; and thus not to look for assistance to that source. Now this conclusion, although a very general one, is far from being universally the case. This erroneous calculation long misled, for instance, the farmers of some of the thin clays of the north of Hampshire, resting upon the chalk formation; the chalk being there so very near the surface soil, no one imagined that a dressing with that could possibly fertilize the thin clay soil which merely covered it to the depth of a few inches; they have found, however, upon a correct examination, such a deficiency of carbonate of lime (chalk) in this thin surface of clay that they have now generally adopted, with great advantage, the plan of manuring these soils with copious dressings of chalk, brought to the surface in some instances by sinking dry wells to a considerable depth. And in another adjoining portion of the same county, the *deep* clays of the district around Strathfieldsaye, it has been found, by the analysis of Professor Phillips, that this apparently uniform clay differs very materially in composition at

different depths. He found (to give an instance) in one hundred parts of two varieties of clay, at 22 inches and at 4 feet 6 inches, per cent. (*Jour. R. A. S.* vol. vii. p. 258)—

	At 22 inches.	At 54 inches.
Silica	59.0	72.9
Alumina	23.5	13.4
Peroxide of iron	8.1	6.6
Carbonate of lime	1.0	[illegible]
Water, sulphate of lime, &c. .	4.8	5.5
Carbonate of magnesia . . .	0.0	9.8

The difference in the composition of the under and upper soils is a too commonly neglected fact, when the owner is considering the best means of increasing their value either by drainage, by fertilizing admixtures of other earths or salts, or by both. This neglect is the more injurious, since it prevents the profitable conversion of many such soils to tillage, renders the growth of turnips impossible, and thus materially keeps down the value of the land. During the drainage examinations of Mr. J. Parkes, this state of things has often forced itself upon his attention. He observes, (*ibid.* p. 249,) that "numerous are the examples which I could cite, of the lower clay of a field being more porous than nearer the surface. Beds of gravel, sand, or mixed earth, also often prevail under superficial clay, at depths not too great to allow of their being profitably used as dressings for the improvement of the soil, and for the drainage to be made, (and be it noted by the farmer, that such facts materially facilitate the better understanding of the most profitable system of drainage,) at distances not too great to allow drainage to be made at considerably wider intervals than if the drains were laid in the clay, effecting thereby the removal of the subterranean water, permitting the descent of rain water, and causing a less outlay of money. The capillary force, or succulency of soils varies greatly, and is often very noticeable. It has occurred to me, in digging test holes previous to drainage, to find the water standing in them not nearer the surface than three feet; yet the surface soil has been so wet that water would drop from it on squeezing with the hands. This would determine me to bleed such soils to the depth of five feet at least, and such drainage has been accompanied with complete success." Having thus availed himself of every facility for the improvement of his poor clay lands, which their varying composition at different depths may afford, having removed the land water and improved the texture of the soil, it will be pretty easy, when the land is thus rendered less cold, tenacious, and free from water, to successfully introduce on many soils the cultivation of turnips. These will often require, as a necessary consequence, the addition to the land, in some fertilizer or other, of the phosphate of lime; without which addition, (supposing always that the soil does not already contain it,) as found either in crushed bones, guano, urate, &c., it is idle to expect remunerative crops of this invaluable root.—(*Bell's Messenger,* No. 2639.)

CLAY ASHES.*

In the manures, available by the farmer for many clay soils, must be placed in a very prominent position, clay ashes or burnt clay, as it is sometimes called. This kind of dressing not only operates beneficially by its *mechanical* effect upon the soil, but it, in its *chemical* operation,

* See *British Husbandry, vol.* i. *p.* 369.

supplies to the soil a considerable portion of charcoal—a proportion which varies in extent according to the care bestowed in their preparation. The observations which I have had occasion to make when speaking of charcoal as a fertilizer, (see *Charcoal*,) are to a considerable extent applicable to the question of clay ashes. As I have remarked in another place, (*Bell's Messenger*, No. 2,629,) it unfortunately happens on many soils that the practice of clay-burning is retarded by the clay baking into hard blocks, more like bricks than ashes, and these of so hard and permanent a texture that they are of very little service to the land. A recent discovery of Mr. Walter Long, to which I shall presently allude, by affording the farmer the means of preventing, in many such soils, this lump burning, will be found most valuable in extending the use of clay ashes. It is always desirable, however, for the farmer, before he commences the preparation of any manure, to be in some degree aware of the chemical composition of the substance he will probably produce. Now, although the earthy portions of clay ashes differ as widely in the proportion of their constituents as that of the various clay soils from which they are prepared, yet we may still form a pretty accurate estimate of the nature of the substances usually contained in clay ashes from the chemical examinations which have been made. These ashes, the young farmer must remember, not only contain the earthy and saline matters of the soil, and of its organic matters, but of the similar substances contained in the wood or other fuel employed in their preparation, with a considerable portion also of their carbon or charcoal; and this last substance, when the amount of ashes employed upon the land is very considerable, is much greater as regards the *extent* of the application of *the charcoal* than many farmers are willing to believe; and this evidently leads to another conclusion, that these ashes, from the absorbent powers which they hence possess, are well adapted to have liquid manures, or other too rapidly decomposing matters, mixed with them, either when they are used as a covering to farm-yards, or for the floors of buildings in which stock are kept, or in the preparation of drill manures. Davy examined the ashes obtained from a variety of soils, principally those by the now nearly exploded paring and burning system. He obtained from 100 parts of the ashes produced, by paring and burning a stiff clay soil, at Mount's Bay, in Cornwall—

Charcoal	8 parts
Common, and other salts	2
Oxide of iron	7
Chalk	2
Clay and sand	81

Supposing, therefore, that 50 tons per acre of these ashes are applied, (a quantity often much exceeded,) we from this analysis perceive that the farmer must often dress his land (in the ashes) with about four tons of charcoal per acre. And hence we may safely conclude that the good effects of such a dressing must be evident for several years, even if we allow but little benefit to be derived from the mechanical effects thus produced on the adhesive soils, to which it is most commonly applied. The expense of preparing these kinds of ashes, per 100 loads, has been thus estimated by a veteran clay-burner, Mr. Poppy, of Witnesham, in Suffolk:—

	£	s.	d.
Labour—Digging and burning, at 9*d*. per load . .	3	15	0
Filling, 1*s*. 6*d*. per score, 7*s*. 6*d*.; Carting, three horses and two carts, 16*s*.	1	[illegible]	[illegible]
Filling and spreading after burning	0	15	0
Carting, and laying out over two acres	0	16	0

Being 6*l*. 9*s*. 6*d*. per 100 loads, or 3*l*. 4*s*. 9*d*. per acre, allowing 50 loads to each. A much larger proportion, however, than this is often applied by the Suffolk farmers; sometimes, indeed, to so large an extent are the ashes employed, that the very staple of the soil must be considerably altered. In a recent letter to Mr. Pusey, (*Jour. R. A. S.* v. 7, p. 142,) Mr. Poppy gives an instance of the success of such a copious dressing. He remarks, "Two years since, I redrained a very poor piece of land at nine feet distance, ploughed it up when tolerably dry in the spring, and burned all I could get taken up with three-tined forks, in heaps 30 yards in circumference, on a space of two acres, breaking the clods as they were thrown on the heaps. When burnt, it was carted and spread on the same land, and the quantity proved to be 30 bushels per rod, or 4,800 per acre. The field was fallowed through the summer, and sown with barley and clover last spring twelvemonth. On a part of the field where not burnt, four cwt. of guano was sown upon the barley; another unburnt portion was manured with town muck; and a third portion, also unburnt, was left unmanured. The barley proved equal in bulk where manured with burnt clay, with guano, and with town muck, the yield being apparently one-third more than where no manure was applied. The present crop of clover (1846), where the burnt earth was spread, is a very heavy crop; also where the town manure was laid; but I cannot see that on the portion where the guano was sown on the barley the clover is the least better than where the land was left unmanured." "In another field," adds Mr. Poppy, "I burnt ditch and bank earth, and laid them on the land for barley, which proved as much superior to the rest of the field as in the other case, and the beans, as far as the burnt earth was spread, are a foot higher than the rest of the field." As relates to the duration of the effect of claying, Mr. Poppy observes—"The beneficial effects of burnt earth may be seen for many years on poor heavy land." And he adds an observation which must accord with the good feelings of every reader when he says—"It is also an unlimited source of employment, and particularly to old men and weak hands, as well as a means of much improving the produce of some districts. Great quantities of earth are burnt for manure every year in this county in the heavy land districts, and such has been the case as far back as the oldest farmers and labourers can remember." The use of the carbon existing in clay ashes, for the purpose of absorbing and storing up liquid manure, is shown by the successful practice of Mr. Walter Long, (*ibid.* p. 245,) who has for some time employed these ashes, in combination with the rich drainage of his farm-yards, in a way which the cultivator of many a farm, far removed from ready access to other organic manures, might very successfully and profitably imitate. And be it noted by the agricultural student, that by this plan not only is an excellent manure produced on the farm in very great abundance, but by the mode thus adopted at Preshaw, in Hampshire, the manure is made to perform another highly important service, that of preserving from decomposition the urine, and other valuable drainage matters of the live stock, until they are needed for the use of the crops of another season. "Our soil," remarks Mr. Long, "is a thin, dry, flinty loam upon chalk, and we suf-

fer unless we have an abundance of rain in spring and summer; everything, therefore, is beneficial to our land that has the property of attracting atmospheric moisture, &c. With this object, the first point is to obtain ashes; those that are burnt in the fields from weeds and grass around the headlands, or from the grubbing of hedgerows, being full of vegetable matter, are the best. These, however, can only be burnt in summer; and sooner or later, in farms that are kept clean, the materials are no longer to be found. Yet an inexhaustible supply may be obtained, and employment afforded throughout the winter, by burning clay and strong earth in kilns protected from rain, the only difficulty having been that many persons, and myself at first, produced a hard substance, more resembling brickbats than powder. This difficulty," continues Mr. Long, "I obviated by (previous to burning) well saturating the soil with water, working it, and treading it to the consistence of mortar; (would it not be still better to add to the clay, if readily obtainable, a portion of peat, tanners' refuse bark, or saw-dust?) for water will separate any particles however adhesive, and then the fire, expelling the water and the carbonic acid gas, leaves the particles in the state of very fine powder; and, if any should not at first be quite separated, it slacks immediately on the application of liquid. Having saturated the soil thus with water, as much as a spade will hold is rolled up to the size of a large cannon-ball, and is handed to a man in the kiln, who places it on the bars or the coping of the brick arches over the furnace. He places each ball as he receives it, for two or three tiers, one above the other, and then lights the bavins in the furnace. In a short time the balls, wet as they are, become set or firm, and will not run into each other, from the accumulated weight. These tiers of balls are then covered with a layer of small roots or wood, (which yield charcoal,) and then over this wood the moist earth is laid on in spits, as loosely as possible, till the kiln is nearly full, and finally topped up with turf, or rape-roots, or any vegetable rubbish. If the first tiers of balls be laid on over night, and the fire is kindled about seven next morning, all work of continuous burning may be so forwarded as to enable the men to block up the mouth of the furnace with roots or stools by five o'clock P.M.; leave it to burn, and go home, and the next morning the whole will be found burnt out. In this way, there being three kilns, and one lighted every morning, one will be cooling, one will be unloaded, and charged again with balls, and one will be burning out, and so in rotation. And by burning off two kilns, any one day at the close of the week, and leaving them to cool, seven kilns may be burnt in each week, each containing about 160 bushels, and thus 1000 net bushels may be obtained weekly. When the ashes are taken out of the kiln, they are sifted very fine, and made free from stones, chalk, &c., and wheeled to a covered shed 50 feet long, and there laid out in beds or pools, embanked by themselves all round, about two feet deep; a portable cask and pump attached then continually brings from various tanks the overflowing of the farm-yards, the liquor from the stables, cow-sheds, piggeries, the house, the laundry, and discharges it into these beds of fine ashes, which, when they have absorbed the liquor, are covered with a coat of gypsum. They are then repeatedly turned, and repeatedly flooded, until they have thoroughly imbibed the moisture, and remain fully charged with valuable matter. It is then packed away in another close shed, or store, and then trodden down by men as hard and as close as you may fancy guano to lie in its rocky bed, and so it remains piled up to the upper tie-beams of the shed, and covered over with boards and hurdles, until dug out with a

pickaxe for use. We thus have always a large store of manure ready to drill for turnips, &c., and a most excellent top-dressing for grasses and meadows; and in the kitchen and flower-gardens it has been found a perfect substitute for farm-yard manure, and less productive of weeds. In its process it heats a good deal, and sends out crusts of saltpetre." I have been induced to refer thus at considerable length to the valuable paper of Mr. Long, (and the young farmer will find in it the plans of the furnaces,) because I feel that much more is yet to be profitably accomplished with the use of clay ashes than has been hitherto attempted. For not only when applied in the ordinary way are they an invaluable addition to many soils, but if the farmer is careful to have them prepared so as to contain as large a portion of charcoal as possible, they then become one of the most powerful and valuable agents to spread over the floors of all covered buildings in which his stock are confined. By a careful attention indeed to this, by the regular and judicious collection and storing of the burnt earth as it becomes nearly saturated with urine, I am quite sure that in many situations the farmer need never be without an abundant supply of valuable manure, the produce, too, of his own ground, and admirably adapted for the supply of the manure drill. The process of clay-burning must not, however, be confounded with paring and burning. The first operation, when properly conducted, not only improves the texture, but adds to the soil a large fertilizing portion of carbon and saline matters from the combustibles employed, whilst the other impoverishes the land of a considerable proportion of useful organic matter, and usually leaves amongst the resulting ashes a very small portion of carbon. Mr. Pusey has given the result of a trial with clay ashes, upon "very heavy Oxford clay land," which supports my previous conclusions. In this case a field of eight acres was selected, and the following was the result per acre of the comparative trials with a wheat crop (*Jour. R. A. S.* vol. vi. p. 478):—

The soil simple produced	37¾ bushels.
„ dressed with 80 cubic yards of burnt clay	45½ „
„ „ with 83 yards of burnt clay and sheep folded	47½ „

It is to such valuable practical exertions as these that I am so anxious to direct the attention of the owners and tillers of the soils to whose improvement I have been thus glancing. I feel that the time is arrived when the progress of the very steady and long deterioration which such lands have in general undergone must be stayed, new efforts made; the tide of improvement, in fact, must begin to flow towards these too long neglected poor descriptions of clays. I deem no apology necessary for this lengthened notice of such a subject, since I am quite certain, that no one who wishes well to the farmers of his country can labour on any lands with more general advantage than upon that great class of holdings which are so proverbially known as "the poor clay farms."

THE CHALK SOILS *.

The chalk soils of England are of peculiar interest to the farmer. They are commonly cultivated with considerable ability by extensive and enterprising holders. From them come some of the finest breeds of our great flock-masters. In their vales, fed by their copious streams, are found the most valuable, extensive, and best managed of all the water meads of this island. This formation, which is divided by the

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geologist into divisions, (the upper, which abounds in flints, and the lower chalk, from which flints are absent,) extends from Bridport to Salisbury, Hungerford, High Wycomb, Stevenage, Saffron Walden, Thetford, Swaffham, and to Docking; from Burgh, in Lincolnshire, to Barton, Hull, and Beverley; and again, commencing at Dover, it extends to Chatham, Guildford, Farnham, Winchester, and Salisbury. The streams which proceed from below the lower chalk, very truly remarks Mr. Morton in his work on soils, " is pure and limpid, and delicious to drink. It contains carbonate of lime, and is of the best quality for water meadows; hence the best water meadows are in the chalk valleys." Soils of the chalk formation are composed chiefly of chalk and flint in varying proportions. These soils are materially improved by mixing them with those of the green sandstone formation, and by inclosing them into much smaller fields than at present. It is always desirable to ascertain, as we proceed, why the addition of one earth increases the fertility of another—what, in fact, the first contains of which the last is deficient. This can only be done by chemical analysis. In the case of the soils of the chalk formation they are found on analysis to be composed chiefly of carbonate of lime and silica, either in sand or in flint. Now the green sandstone, which is found immediately under the chalk, it will be seen from the following analysis contains a large portion of alumina (clay) and potash, in both of which the chalk soils are generally deficient. The green sandstone is composed chiefly of siliceous sand, mixed with two other earths, called mica and chlorite. These are composed per cent. of

	Mica.	Chlorite earth.
Silica	47.0	50.0
Alumina	20.0	26.0
Lime	00.0	01.5
Oxide of iron	15.5	05.0
Oxide of manganese	01.7	00.0
Potash	14.5	17.5
Loss	01.3	00.0

In those places, too, where the chalk and the clay formations unite, the fertility of both these soils is very materially improved by an interchange. There is no principle, in truth, more certain and more beneficially remembered by the farmer, in the consideration of any proposed *permanent* improvement of the soil, than that it is the *excess* of any one earth in a soil which commonly causes that land to be barren, whether it be alumina, (clay,) carbonate of lime, (chalk,) or silica, as presented in sand or gravel. It is noticeable, however, that an excess in the proportion of the carbonate of lime present in a soil is much less injurious than that of a much smaller proportion of either sand or alumina. It behoves, however, the holder of such soils to consider the advantage of such green sandstone or clay dressings, for, wherever they can be practically used, the advantage of their employment is undoubted. A large breadth of the chalk formation exists in a state of nature, as downs or sheep walks; few attempts have ever been made to improve these, and when they have been brought into cultivation as arable, from various erroneous calculations and hastily adopted systems of cultivation, the success of the effort has often been very discouraging. Here we have the very sound and practical evidence of Mr. Bravender. (*Jour. R. A. S.* vol. vii. p. 161.) He says, going at once to the ordinary error, " It might be assumed that because one person may have obtained with artificial manures an excellent crop of wheat from a thin down soil, all such

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Loss	01.3	00.0

In those places, too, where the chalk and the clay formations unite, the fertility of both these soils is very materially improved by an interchange. There is no principle, in truth, more certain and more beneficially remembered by the farmer, in the consideration of any proposed *permanent* improvement of the soil, than that it is the *excess* of any one earth in a soil which commonly causes that land to be barren, whether it be alumina, (clay,) carbonate of lime, (chalk,) or silica, as presented in sand or gravel. It is noticeable, however, that an excess in the proportion of the carbonate of lime present in a soil is much less injurious than that of a much smaller proportion of either sand or alumina. It behoves, however, the holder of such soils to consider the advantage of such green sandstone or clay dressings, for, wherever they can be practically used, the advantage of their employment is undoubted. A large breadth of the chalk formation exists in a state of nature, as downs or sheep walks; few attempts have ever been made to improve these, and when they have been brought into cultivation as arable, from various erroneous calculations and hastily adopted systems of cultivation, the success of the effort has often been very discouraging. Here we have the very sound and practical evidence of Mr. Bravender. (*Jour. R. A. S.* vol. vii. p. 161.) He says, going at once to the ordinary error, " It might be assumed that because one person may have obtained with artificial manures an excellent crop of wheat from a thin down soil, all such

land ought, therefore, immediately to be broken up and cropped with wheat; but this would not be a fair mode of testing such a step. The wheat crop is only one of a course, and before the farmer can place the least faith in any calculations the expenses and produce of the entire course must be laid before him. Some of the crops of such a course are not paying crops, and these should be balanced against those that pay. If we take the first crop of wheat only, and assume that we shall always obtain the same quantity, we may discover too late that we have difficulty in obtaining the same amount of produce again. Hence we must ascertain what would be the probable produce continuously under proper cultivation when the first flush of the soil has vanished. To settle our notions on the subject, if they are wavering, let us make the inquiry, Would it be advisable to break up all the chalk downs in England? My reply would be, 'I think not.' Those which are much elevated or very thin would not bear corn crops except at long intervals. Those not too much elevated would produce sainfoin and perhaps vetches and turnips, and a corn crop now and then, but would probably pay better in down, depastured as now, by sheep folded on the arable land at night. If such lands, after being broken up, could not be maintained as arable, it would be a great mischief to have broken them up at all, because years would be required to restore such scanty sward as our downs now produce. I shall, therefore, hesitate to recommend the breaking up of land very much elevated, or of very thin downs. For keeping large flocks of sheep on down land, and folding them on the arable lands, renders it unnecessary for the farmer to purchase artificial manures, and enables him to farm in a four-field course, on a soil naturally fitted for only a five or a six-field course, adding also one-third to the produce of the wheat crop, and in some cases nearly doubling it. The difference of production of the wheat crop has been estimated by those more competent than myself at eight or nine bushels per acre more, on a farm with one-third of its extent in down, and where folding is practised, than on one of a similar soil where that practice is not available. This additional produce, which is due to the down, would be gradually lost, and each field on the farm thrown entirely on its own resources, or manures must be purchased to supply the place of that now derived from the downs by means of sheep; still any portion of downs with a tolerably deep soil, and adjoining the land already in cultivation, may be converted into tillage. In many parts of the downs, however, the farmer has gradually moved up the hill-side until the chalk rock shows itself on the surface, which indicates that he has advanced as far up as is advisable." Such are the cautious calculations which the farmer should employ before he breaks up the thin soiled down land of the chalk formation. But when these are broken up, and in those cases, too, where the soil is found too poor for the ordinary mode of cultivation, it then becomes of the most considerable importance to determine, as this poverty is owing to the absence from the soil of certain chemical ingredients essential to the luxuriant growth of the farmer's crops, if these ingredients cannot be profitably supplied. It was this great question that not long since engaged the attention of an enlightened Dorsetshire agriculturist, the Rev. A. Huxtable; and his experiments, although made on the chalk, may be advantageously studied by the occupiers of many a poor field on other formations. He very clearly tells us, (*Jour. R. A. S.* vol. vi. p. 356,) "The problem which I sought to solve is contained in the question, 'Can we by supplying to the soil the constituents (so far as is yet known) of a plant, cultivate that plant on any land,

however in itself sterile?' The portion of ground chosen for the testing of the principle here implied is situated in the parish of Sutton Waldron, in Cranbourn Chase, very steep, exposed to the south, but sheltered in some degree by the hills, of which it forms a part, almost covered with the white rubble forming a portion of the 'upper chalk.' This precise spot, consisting of five acres, was selected, because it appeared the most barren and 'unlikely' of any in the immediate neighbourhood. In truth, the endeavour to grow swedes on such land appeared to all observers an *experimentum crucis*. So long as it lay in down, scarcely any herbage whatever covered this hill-side. On the failure of the hay crop in 1834, a party of poor men came to me from Shaftesbury, soliciting employment. They were set to dig this piece of land, but the soil proved too thin and stubborn for the spade; they, therefore, in their own phrase, knocked it over with the pickaxe. Twice in the season after it was sown with rape, but the produce was nothing. A soil of this constitution seemed a fair field for the experiment, on a pretty large scale, and in 'a popular way.' I say in a popular way, because, to satisfy the requirements of rigid science, a strict analysis both of the soil and manure would be asked for before any inference would be permitted to be drawn from the result. Yet for practical purposes it may seem enough to show that on land growing nothing a large crop can be raised by adding certain ingredients which, the chemist tells us, are necessary for that crop. Accordingly, in the latter part of April 1845, I determined on this hill as above described to see whether it were possible to produce a crop of swedes weighing 20 tons per acre. To effect this object chemical analysis, as given in Professor Johnstone's Lectures on Agricultural Chemistry, acquaints us that there would be required for the bulbs and tops of such a return, (20 tons of bulbs and 5½ tons of tops,) inorganic matter weighing more than 500 lbs., consisting of about 146 lbs. of potash, 76 lbs. of soda, 69 lbs. of sulphuric acid, 30 lbs. of phosphoric acid, 103 lbs. of lime, 22 lbs. of magnesia, 23 lbs. of chlorine, 23¼ lbs. of silica, as well as a certain proportion of organic matters in the form of ammonia and carbonic acid." I need not give here the other reasons which induced the selection of the following ingredients, it will suffice if I add their cost and the result. "I rejoice," remarks Mr. Huxtable, "for the sake of the labourer begging for work, and the nation for food, that I can answer the inquiry most satisfactorily. Thus stands the cost per acre:—

30 bushels of wood ashes, at 6*d*.	£0	15	0
2 cwt. of Ichaboe guano, at 7*s*. 6*d*.	0	15	0
50 lbs. of burnt bones and 22 lbs. of sulphuric acid	0	7	0
30 bushels of sawdust	0	2	6
Labour account in hoeing, drilling, dropping seed (the surface of the land being otherwise untouched)	0	19	6
10 lbs. of sulphuric acid, poured over ashes	0	1	3
Rent 6*s*.; rates, &c., 2*s*.	0	7	0
Seed, 5 lbs. per acre	0	3	6
A pair of horses hauling the artificial manure to the summit of the hill	0	7	0
	£3	17	9

The issue of this experiment," adds Mr. Huxtable, "has exceeded my most sanguine expectations. Forty perches of the best part of the land yielded, of *clean* roots, after the rate of 23¾ tons per acre; whilst 40 perches of the poorest gave 19 tons. Competent persons have estimated

the crop at 21 tons per acre of clean roots, the samples of which were weighed in dry weather. One remarkable circumstance presented itself to the observer: between swedes of 8 lbs. and 9 lbs. weight would be seen, every now and then, a starveling plant, in bulb not bigger than a marble. This arose from the carelessness of the children, who occasionally dropped the seed at a distance from its appointed food. But these accidents served to prove, beyond all doubt, at once the efficiency of the manure and the intrinsic poverty of the ground." Such, then, are a few only of the important considerations, such some of the errors to be avoided and difficulties to be overcome, in the patient and scientific efforts of the holders of the poor chalky soils of England. I commend the investigation, (a research on which the improved cultivation of many thousands of acres depends,) not only to all those immediately interested, but to all those who, from an imperfect acquaintance with its pursuits and its manifold difficulties, are too apt to very complacently regard farming as a "very easily followed business."—(*Bell's Messenger*, No. 2645.)

LIME *.

In addressing the members of the chemical section of the Southampton meeting, in 1846, upon "the rationale of certain practices employed in agriculture," Dr. Daubeney made some valuable remarks upon the use of lime. This fertilizer, although extensively employed in many considerable districts of England, is too often applied to so great an extent for a series of years, that at last it entirely fails in producing profitable results. Its mode of operation, therefore, can hardly fail of being interesting to the farmer. It seems to be pretty well ascertained that the beneficial action of lime upon most soils must be attributed to *various* causes. Dr. Daubeney and Mr. Prideaux, in allusion to its action on some of the soils of Devon and Cornwall, consider that it operates beneficially by promoting the disengagement of potash and other substances from the materials of the soils; or, to express the same thing in another way, by converting the dormant earthy or saline constituents of the soil into such an active state as to become immediately available to vegetation. In support of this view of the case, the fact was alluded to, that the soil of a field, exhausted by long-continued cropping, was found to yield double the quantity of potash after being previously dressed with lime. The action, therefore, of the lime upon the *earthy* matters of many soils is exceedingly beneficial. The frequent application of lime, however, tends to exhaust such soils, by the rapid reduction of the proportion of their potash, not only by furnishing it more copiously as a constituent to the growing crops, but by dissolution in the water draining from the land.

But the beneficial action of lime is not confined to its chemical effects upon the *earthy* portion of the soil, since its operation upon the vegetable and animal matters therein contained is peculiarly powerful; and to this cause upon many soils its chief value as a manure must be attributed. In this respect I am quite prepared to concur with Professor J. F. Johnston in his conclusions, from all the trials at which I have had the opportunity of being present, that the lime appeared to produce very slight effects upon those lands in which organic (animal or vegetable) matter is deficient; that its good effect is not generally so considerable, during the first year of its application, as that which it pro-

* See "*British Husbandry*," vol. i. p. 283.

duces during the second or third years; that its effect is more decided when it is (as by being used as a top dressing) kept near the surface of the soil; and that this effect gradually diminishes as the lime sinks into the earth; and, moreover, that by the use of lime, the organic matters of the soil not only more rapidly disappear, but that, as these are diminished in quantity, the addition of more lime produces a much less sensible effect in promoting the fertility of the soil.

And not only does the re-application of lime cease to be advantageous to the soil, but in many cases an excess becomes absolutely injurious. "The term *over-liming*," observes Professor Johnston, (*Trans. H. Soc.* v. 9, p. 480,) "is one well known to practical men, especially in the northern end of the island. It has been long observed, that after land has been frequently limed, and kept under arable culture for a series of rotations, it gradually acquires a lighter and a more open character. It thus becomes less fitted for the growth of those plants which delight in stiff and compact soils: the wheat, for example, becomes less certain, and is apt to be thrown out by the frost. It is partly in affording a remedy for this evil that the rolling and pressing of wheat land has been found of so much advantage. But in soils which are naturally light, and especially in such as abound in vegetable matter—in peaty and in moorish districts which have been reclaimed by the aid of lime, amongst other means—this opening up or loosening of the soil often takes place to a very much greater extent. The surface appears to be heaved up, and the land sounds hollow and sinks under the foot. This appearance has been so often observed or supposed to follow from the application of large doses of lime, that it is usual among practical men to speak of it as the immediate effect of *over-liming*, and to pronounce, wherever it is observed, that the land is *over-limed*. In this loose and open state, turnips, potatoes and barley, thrive well upon it; but oats and clover sometimes almost fail." Several of the sorts of such over-limed soils, from Ballindalloch, were analysed by the Professor, to determine if these effects were produced by the presence of too large a proportion of carbonate of lime in them, but the five specimens did not prove the truth of such a supposition, for they were found to contain, respectively, per cent. of carbonate of lime, only 1.40, 0.69, 1.10, 0.98, and 0.67.

The lime applied to the soil, however, is sooner or later gradually exhausted; it is diminished in quantity by its being soluble to a certain extent in water, (500 parts of water being capable of dissolving about one part of lime;) consequently, the soil is gradually and steadily deprived of its lime by the water carrying it either deeper into the earth or into the drains.

The improvement of the hill pastures of our island may, perhaps, be advanced by the consideration of these facts. "The rains," observes the Chemical Society of Scotland, (*Trans. High. Soc.* 1846, p. 313,) "which fall on high districts of country, naturally dissolve many substances over which they flow, or through which they penetrate. Among these substances lime is one which is always present in our mountain and hill streams when they reach the lowlands that border them. In course of time, therefore, the soil of every sloping country ought to become poor in lime, from the action of this cause alone; and as lime is necessary in our climate to the luxuriant growth of all our cultivated crops, the addition of lime to such land may be expected to increase its productiveness." The practice of many intelligent farmers verifies the correctness of this conclusion. Mr. Stewart, of Hillside, (*ibid.* p. 314,)

finds, as a dressing for old pasture lands, that lime is superior in its effects to even crushed bones. I have no doubt but that, in the improvement of such hitherto generally neglected soils, the use of lime will, from its cheapness, powerful effect, and lightness of carriage, be found a very powerful agent.

But there is another source by which the soils of all cultivated lands are always impoverished of their calcareous matters, viz., in the constituent portion of the farmer's crops which is composed of lime. This is much greater in amount than is generally understood. Professor J. F. Johnston (*Chemistry*, p. 207) has given the weight of lime carried away in several of them; it is as follows:—

25	bushels of wheat,	remove from the soil,	of lime	9 lbs.
50	„ oats	„	„	9 „
38	„ barley	„	„	15 „
2	tons of rye grass	„	„	33 „
2	„ red clover	„	„	126 „
25	„ turnips	„	„	140 „
9	„ potatoes	„	„	270 „

There are also several acid matters in the soil, which combine with the lime, and form various salts of lime, all more or less soluble in water; and this is another means by which lime is removed from the land. There are, therefore, one or two circumstances of great practical importance to be regarded in the application of lime; some of which, we have already seen, have been alluded to by Professor Johnston. (*Ibid.* 207.) He adds, in another place, "The largest doses which are applied in practice alter in a very immaterial degree the chemical constitution of the soil. The best soils generally contain a natural proportion of lime, not fixed in quantity, yet scarcely ever wholly wanting. But an ordinary liming, when well mixed up with a deep soil, will rarely amount to one per cent. of its entire weight. It requires about 400 bushels, or 12 to 15 tons of burned lime, per acre, to add one per cent. of lime to a soil of 12 inches in depth—if only mixed to a depth of 6 inches, this quantity would add about two per cent. to the soil."

It has recently been found, that on many soils in the north of England the lime is much more durable in its effects if it is previously slaked, by either the application of water or by exposure for some time to the atmosphere, as in the heaps on which it is deposited on the land. I have found also the advantage, when lime is applied to light land, of previously mixing it with earth, and allowing the heap to remain for two or three months before it is spread on the soil. Mr. Anderson, of Gorthleck, has made a similar observation; he considers it (*Trans. High. Soc.* v. ix. p. 94) "advantageous in some cases to apply the lime in the form of compost, with clay earth or sand. A sort of artificial marl is thus formed, which is advantageously spread on grass lands, affording them additional nourishment. When the object is to improve the texture of a soil of sand, or clay, or peat, a compost has much to recommend it, lime combined with sand being best adapted to an aluminous or peaty, and with clay for a silicious soil. A compost in such cases has been found to be eminently beneficial and preferable to the application of unmixed lime." The effect which lime produces in common with several of its salts, of inducing the germination of particular seeds, has been noticed by Mr. M. Turk, (*ibid.* p. 129;) there is none, he truly remarks, in which it is more remarkably the case than in that of white clover; and, at the same time, there is no plant more desirable to be obtained. When lime is applied to the surface of

pasture land of so inferior a quality that clover has not before made its appearance, and if the land is *not so wet* as to counteract the influence of the lime, in the course of the second year after its application white clover is almost certain to appear."

The farmers of the northern portion of our island, who principally obtain their lime from limestone, are, generally speaking, hardly sufficiently particular as to the quality of the stone they employ—this varies very considerably. Thus, some of the limestones of Argyleshire, have been found by Professor Johnston to contain, (*Trans. High. Soc.*, 1847, p. 574,)

Carbonate of lime	90.14
Carbonate of magnesia	0.31
Alumina, and oxide of iron	0.51
Insoluble silicious matter	9.08

The lime obtained from such limestone would not contain so large a portion of magnesia as to be injurious to vegetables; other limestones, however, are of a very different description; specimens from Berwickshire, contained, (*ibid.* 577,)

	From Langton Park.	Langton Wood.	Grueldykes.
Carbonate of lime	43.85	47.00	43.81
Carbonate of magnesia	33.34	38.04	39.50
Alumina and oxide of iron	1.59	1.99	3.57
Insoluble silicious matter	21.41	12.97	13.09

I need hardly warn my readers against the application of lime mixed with the manure of the farm-yard, the action of the lime being very injurious to the compost; but, on the other hand, there are few substances more powerful than this, when mixed with peat, to reduce the latter to such a state of decomposition as renders it most serviceable as a manure.

In some districts where lime is scarce, the farmer's attention may be profitably directed to the lime refuse of the manufacturers. That of the gas-works is very valuable, especially when, previously to its use, it is mixed with a very large proportion of earth, such as pond mud, ditch scrapings, &c. This lime abounds, too, with hydrosulphuret of lime and other fertilizing substances. The lime of the bleacher is also sometimes available for the same purpose, not only for the large proportion of carbonate of lime which it contains, but for the value of its foreign matters. A specimen of this bleacher's refuse lime analysed by M. Fromberg, (*ibid.* p. 200,) yielded—

Organic matter and water	18.57
Sulphate of soda and sulphuret of sodium	14.23
Oxides of iron and alumina	5.07
Carbonate of lime	55.18
Silicious matter	6.60

Like the lime of the gas-works, this should be used only after having been previously mixed with earth; for otherwise the large proportion of its saline matters will be found, when first applied, much too powerful in its effects. These observations and experiments may perhaps be useful at this period of the year to the farmer in his efforts to not only improve the fertility of the land already partially reclaimed, but those extensive upland wastes, which have never hitherto had much attention paid to them. That such lands are to be profitably and extensively improved there is little reason to doubt, and the present we are all aware is not a

period when any soils can be neglected, or any improvements disregarded that prudence and enterprise suggest.

HEATH SOILS *.

The last class of soils on which I shall remark in this work are the poor heath soils, which abound in many districts of our islands, many thousand acres of which have, it is true, been successfully reclaimed within the last few years, but with which a vast breadth of land is still occupied.

The cultivation of these heath soils, although commonly attended with considerable difficulties, may still in very many instances be profitably accomplished. They are composed, however, as I have elsewhere remarked, (*Bell's Messenger*, No. 2647,) of such varying ingredients, are placed at such widely different elevations above the level of the sea, the materials for their improvement are so differently placed in regard to their use on such soils, that we can only, in endeavouring to address ourselves usefully to their consideration, dwell upon those means of improvement which are pretty commonly available in most situations. The heath soils of the south of England, such as those of Bagshot and the New Forest, are composed chiefly of a hungry gravel, with often a closely bound mixture of earth, interspersed with such masses of small silicious whitish-looking stones, that at the first appearance we are very naturally led to the conclusion, that such soils abound in calcareous matter. The analysis, however, of these heaths shows that it is to a deficiency of carbonate of lime in these soils that one chief cause of their natural sterility must be attributed. Alumina, too, (clay,) is very often totally absent from the heathy soils of these southern districts. Thus 400 parts of the soil of Bagshot Heath were found by Sir H. Davy to be composed of—

Coarse silicious sand	380
Fine silicious sand	9
Iron clay and chalk	11

It will not be unattended with benefit if the young farmer compares the analysis of a still uncultivated heath soil, like this, with that of the turnip soils of Holkham, in Norfolk, which were once quite as barren heath lands as those of Bagshot, before the days of the great Coke, and prior to their being copiously clayed or marled. Davy analyzed one of these too, and he found in it eight parts in nine of silicious sand, with various finely divided matters, which were composed, per cent., of (*Ag. Chem.* p. 175)—

Carbonate of lime (chalk)	63
Silica (earth of flint)	15
Alumina (earth of clay)	11
Oxide of iron	3
Vegetable and saline matters	5
Moisture	3

The cause of the sterility of these sandy heaths is, therefore, pretty evident; they are deficient in a proper proportion of clay and chalk. Claying and marling, therefore, are the self-evident and permanently fertilizing additions to such soils; but then it often happens that neither of these are to be obtained at a sufficiently reasonable distance to authorize their profitable employment, and hence the farmer is led to prefer, for a majority of such soils, more especially in the north of England, lime,

* See "*British Husbandry*," *vol.* i. *p.* 280; *vol.* ii. *p.* 108.

which is not only to be generally procured on much easier terms, but possesses the advantage of promoting in some degree the decomposition of the remains of the heath plants, and the peat and other matters often either resting upon or contained in the soil. A recent improvement in the mode of applying lime will also very materially increase the value of its application to such lands. It consists in merely having the lime applied to the soil *slaked* some months before it is spread; by this means the lime becomes less soluble in water than when recently prepared, and is thus not so readily dissolved by the rains, and carried away by the drainage-water; for we must not forget that the lime not only beneficially operates upon the soil in the manner to which we have before alluded, but that it will afterwards, as carbonate of lime, be needed as an ingredient of all those crops which the farmer can profitably cultivate. (See *ante*, p. 92.)

It is noticeable, in the natural symptoms of barrenness which a soil usually affords, that the presence of the furze very often indicates a soil which is readily brought into cultivation. It is to this kind of heath land that the farmers of the south of England so successfully apply copious dressings of chalk; and it is further worthy of remark, that the ashes of the furze contain a very considerable proportion of lime. In some specimens obtained from Arthur's Seat, near Edinburgh, nearly one-fifth of the ash, (*Trans. H. Soc.* 1847, p. 587,) and in a still larger proportion, in the furze of Carnarvonshire. (*Jour. R. A. S.* vol. vi. p. 397.) This last-mentioned specimen contained in 100 parts—

Potash	34.4
Soda	0.3
Lime	29.9
Magnesia	5.5
Sulphuric acid	11.2
Chlorine	4.9
Phosphoric acid	3.6
Persulphate of iron	5.4
Silica	4.8

It is too commonly believed that the necessary expenses of reclaiming poor heath land far exceed the profits derivable from their cultivation. Yet no one who has noticed the good crops growing in cottagers' gardens adjoining the line of the South Western Railway, where it crosses the great heaths of Surrey, will doubt the possibility of rendering such land productive at a very moderate cost, for in these instances the poor cottagers have had little else to assist them except their spades. They have deepened and drained their land, mixed the soil of which their gardens are composed by deep digging and trenching, and the sewage of the house has been all the manure they have had to aid them; the result, however, has been productive crops and increasing fertility. And, on a larger scale than this, let us examine the testimony afforded to us by two enterprising farmers, the one of Scotland, the other of the north of England, both able and experienced cultivators. Let us begin with a farmer of the county of Ross. "I have," says Mr. W. Dick, of Killearnan, (*Trans. H. Soc.* vol. i. p. 618,) "altogether improved 50 acres, of which above 30 acres have been brought under the plough during the last three years. The surface of the ground was generally covered with short stunted heath, the pasturage on which was probably not worth more than 2*s*. per acre, the soil, a clayey gravel, in some cases inclining to peat on a subsoil of wet clayey gravel. The ground was trenched 12 inches deep, with the exception of three acres, which

were taken in with the plough, and about 25 acres were partially furrow-drained at 18 and 24 feet apart, according to the retentive nature of the subsoil. Large open drains were made to sub-divide the ground into fields." The expense of these improvements (and it is this with which we are now chiefly interested) is as follows:—

Trenching 28 acres at 6*l.* per acre	£168	0	0
Ploughing 3 acres and taking out the roots . .	6	0	0
Clearing the ground of roots, stones, and levelling	62	0	0
3353 yards of large covered drains at 2*d.* . .	27	18	10
2975 ditto of large open drains at 1½*d.* . . .	18	11	10½
20,398 ditto of furrow drains at 1*d.*	84	19	10
	£367	10	6½

Making an average per acre of 11*l.* 17*s.* And then as to the result: "The first crop was taken in 1843 from about 10 acres, which were well limed, and manured with farm-yard dung, and sown with barley, which yielded a pretty fair crop of about 4 qrs. per acre. In the following year, 1844, this ground was pastured. In 1845 it was broken up for oats, which yielded a very fair crop, probably 5 qrs. per acre. The remaining 20 acres were prepared for oats in 1844 by manuring and liming, and the crop was a fair one, at least 5 qrs. per acre. In 1845 this portion was under turnips and potatoes, the potatoes being a good crop, but the turnips were below an average." Such is the result of the practice of a Scotch farmer, in reclaiming heath land. Let us now hear what is to be accomplished in the county of Westmoreland, according to the statement given by Mr. John Watson, of Kendal, (*Jour. R. A. S.* vol. vi. p. 86,) who has given the following statement of the expenses incurred in reclaiming 10 acres of heath land. It will be noticed that his estimate is considerably below that of Mr. Dick, and his drainage seems to be much less expensive and complete than that of the Scotch farmer. In this statement Mr. Watson intended to adopt what he considered a fair medium as regards the cost of lime and labour, as well as the nature of the ground:—

Cost of fencing 65 rods of stone fence, (7 yards to the rod,) where stones can be conveniently obtained, including stone getting and cartage	£26	0	0
60 rods of drain, either stone or tile drain, cartage, &c. . .	5	10	0
Paring 10 acres, at 14*s.* per acre	7	0	0
Burning 10 acres, at 3*s.* per acre	1	10	0
150 imperial bushels of lime per acre, at 3*s.* per bushel . .	22	10	0
Cartage of lime 2 miles, at 1*d.* per bushel	7	10	0
Spreading of lime and ashes, at 4*s.* per acre	2	0	0
Ploughing 10 acres, at 10*s.* per acre	5	0	0
Grubbing stones after the plough and clearing the stones off	2	0	0
New gate-posts, &c., probably	1	0	0
Total cost per acre 8*l.*, or . .	£80	0	0

"If," very judiciously adds Mr. Watson, "we estimate the average cost at 12*l.* per acre, (which he thinks a high figure,) and suppose that it required a couple of years instead of one to pay for reclaiming the land, surely the improved state of the land, to the extent of three or four times its previous value, ought to be a sufficient inducement for us, in the present state of things, to reclaim all our barren heaths which are capable of so great an amelioration." His estimates, it seems, "are founded on an average of 20 years, and upwards of 2000 acres of re-

claimed heath land." The erroneous *after treatment* of reclaimed heath land is, I believe, one chief reason why more land of this description has not been reclaimed. The holder's attention has been much too exclusively directed to the first crops; finding that these, by the effects of paring, burning, and liming, yielded a good return, he paid no regard to future years: reserving his manure for better because older land, he was at no pains to restore to the soil what the crops took from it, and as a necessary result, as in succeeding years these became less productive, the land was less regarded. "Farmers in general," adds Mr. Watson, when speaking of the Westmoreland inclosers, "are too apt to plough and rake away at the land so long as it is in high condition and produces a crop of any description, never looking beyond their immediate profit. They scour away at it as though it could never be exhausted; take two or three white crops in succession, without returning back to the land the manure created by it. Sometimes a green crop, which is drawn, succeeds a host of white ones, then another white crop, and sometimes two. The land is at length sown down with grass seeds, which are mown the following year, and then, without allowing the land breathing time, the plough is again stuck in, and another scourging routine of cropping pursued similar to that already detailed." And in his concluding observations we cordially agree, when he remarks that too much ought never to be taken from any lands. Whatever is taken from them in the shape of produce ought invariably to be returned to them in the shape of manure. To build up and never pull down is a maxim that ought always to be kept steadily in view; they ought to be well fed and supported, yet never overworked; exercised and taxed in moderation, seasonably and regularly, but never beyond their powers. Adhering to such principles we may safely and surely hope for their progressive amelioration and permanent improvement.

OF PEAT SOILS.

For the mixture of peat with farm-yard manure, and other matters relating to the cultivation of boggy and peaty soils, I refer the reader to Mr. Dixon of Hathershaw's account, (*Jour. R. A. S.* vol. i. p. 135,) and Mr. Pusey's detail of the Lincolnshire fen land cultivation. (*Ibid.* vol. ii. p. 390.) He will also find an abstract of these in my "Farmer's Encyclopædia," and also in my work on "The Fertilizers;" see, also, *British Husbandry*, vol. i. p. 414.

FARM-YARD MANURE *.

This manure has often been well regarded as, after all, the mainstay of the farmer. The earliest agricultural writers carefully warned the farmer to pay particular attention to this great friend, this chief foundation of success: "study to have a large dunghill," exclaims M. P. Cato, when two thousand years since he was addressing the Italian farmers. He was even aware, in some degree, of the enriching value of vegetable oils, for he advises the cultivators of his day to add to their manure stores *amurca*, or dregs of oil. The last few years have been productive of many valuable researches upon the practical economy of farm-yard manure; and in these not only have the excreta of live stock been examined much more carefully than heretofore, but a similar degree of chemical accuracy has been evinced in the examination of the straw and

* See "*British Husbandry*," *vol.* i. *p.* 226.

other vegetable remains of which so large a portion of the ordinary manure of the farm-yard is composed.

It has been found that the same quantity of the straw of different cereal grasses, and corn, and roots consumed by live stock, produces different weights of manure. This was determined experimentally by M. Block. He ascertained that 100 lbs. of chopped rye-straw given as food to horses will yield about 42 lbs. of dried excrements, (fluid and solid,) 100 lbs. of hay will yield about 45 lbs., 100 lbs. of seed oats will furnish about 51 lbs., 100 lbs. of seed rye 58 lbs., the same weight of potatoes 14 lbs., mangel-wurzel 6 lbs., and green clover 9½ lbs.; the proportion of excrement produced by various animals naturally varies with their size, and the food on which they are fed. It has been calculated from the results of various experiments that an ordinary cow, fed in the usual way, produces about nine tons of solid dung in the course of the year. (*Farmer's Magazine*, vol. xxiv. p. 533; *Sprengel*, 1 *Jour. R. A. S.* p. 461; see, also, *British Husbandry*, vol. i. p. 225.)

In the recent experiments of Dr. Thomson upon the fattening properties of malt and barley, he found that in fourteen days a cow, consuming 1426 lbs. of grass, produced exactly 1000 lbs. of dung. (*Parl. Paper*, p. 45.) But when the same cow was fed for sixteen days on 3 lbs. of barley, 168 lbs. of malt, and 472½ lbs. of hay, she produced 1259 lbs. of dung. (*Ibid.* p. 47.) Again, the food of this cow was varied: she was fed during ten days with 90 lbs. of barley, 27 lbs. of molasses, and 274 lbs. of hay: the dung she now produced weighed 866 lbs. (*Ibid.* p. 49.) She was then fed for ten days with 80 lbs. of barley, 40 lbs. of linseed, and 249¼ lbs. of hay; she now produced 785 lbs. of dung. (*Ibid.* p. 49.) This gives the proportion of solid excrement voided by a cow. M. Boussingault has experimentalized upon the same subject, as may be seen from the following table of the component parts of the food consumed by and of the excrements of a horse and a cow, during twenty-four hours. (*Liebig's Organic Chemistry.*) The weights in this table are given in grammes, a gramme being equal to 15.434 grains.

Articles of Food.	Weight in fresh state.	Weight in dry state.	Carbon.	Nitrogen.
BY THE HORSE.				
Hay	7,500	6,465	2961.0	97.0
Oats	2,270	1,927	977.0	42.4
Water	16,000	...	...	...
Total	25,770	8,392	3938.0	139.4
Total excretions in same time	15,580	3,827	1472.9	115.4
BY THE COW.				
Potatoes	15,000	4,170	1839.0	50.0
After grass	7,500	6,315	2974.0	151.5
Water	6,000	...	...	...
Total	82,500	10,485	4813.4	201.5
Total excretions in twenty-four hours	45,152	6111.4	2601.6	174.5

Other persons have, in various experiments, investigated the amount of dung produced from a given weight of food and fodder taken together, and the results of one of these series of experiments have been given by Professor Johnston, in his valuable work, "The Elements of Agricul-

tural Chemistry," p. 140. From these it appears that one ton of dry food and straw gives a quantity of farm-yard dung, which weighs,

When recent, from	46 to 60 cwt.
After six weeks	40 to 44 ,,
After eight weeks	38 to 40 ,,
Half rotten	30 to 35 ,,
When pretty rotten	20 to 25 ,,

So that we see from these experiments that when only half rotten, farm-yard dung does not weigh more than two-thirds of what it does when in the recent state. This loss of weight is caused partly by the evolution of a quantity of the gaseous matters of putrefaction, and partly by the aqueous matter drained from the heap, or emitted in the shape of steam; a loss which can easily be diminished in amount, although not prevented even then in a considerable degree, by employing the manure of the farm-yard in as recent a state as possible. There is a very practical question, namely, the state in which the farm-yard should be kept during its manufacture, and as to the value of the resulting compound produced. A great many of the farmers in my neighbourhood, in the county of Essex, believe that the farm-yard cannot be kept too dry; and that was the opinion of a great farmer in Dengy Hundred, a tenant of the celebrated Mr. Cline, the surgeon, for he covered in the whole of the farm-yard with a roof. He, therefore, was clearly of opinion that to have manure in as dry a state as possible was most productive, and that it insured a manure of the most fertilizing description. Others, however, are of a very different opinion. This leads to another portion of the inquiry, as to the most desirable state of dryness or of moisture in which the dung of a farm-yard can be kept while preparing. On this important point I have received very discordant opinions from practical farmers; many contending that it can hardly be prepared in too dry a state; whilst others have stated to me as their decided opinion, that if the escape of all *drainage* from the farm-yard is prevented, then the dung can hardly be kept too wet. There are certainly, in favour of this latter conclusion, the results of some recent experiments by the celebrated German chemist, Sprengel, which would lead to the conclusion that at least the putrefied urine of the farm-yard becomes very considerably richer in ammonia when previously mixed with a considerable portion of rain-water. This discovery shows the value of experiments, even when it may be thought that those researches can hardly lead to much good. For if any chemist had been asked, if by mixing a quantity of water with urine and then putrefying it, such a process would add to the bulk of ammonia, that chemist would most probably have answered, " No." But that it does increase the bulk of the ammonia, and that not to a small, but to a very considerable extent, is beyond dispute. Now, upon the quantity of ammonia contained in farm-yard manure, its fertilizing powers to a very considerable degree depend. M. Sprengel analyzed urine in three different states—1. When fresh. 2. After being putrefied by itself. 3. After being putrefied and previously mixed with its own bulk of water. When fresh, 100,000 parts he found to contain 205 parts of ammonia; but after putrefaction this proportion of ammonia was increased to 487 parts, or considerably more than doubled; and when watered previously, it was then found to contain, after putrefaction, 1622 parts of ammonia, or nearly eight times the quantity it did when fresh. The following are the results of his analysis (*Farmer's Almanack*, vol. ii. p. 31):—

	Fresh.	Putrid.	Watered.
Urea	4,000	1,000	600
Albumen	10	...	...
Mucus	190	40	30
Benzoic acid	90	250	120
Lactic acid	516	500	500
Carbonic acid	256	165	1,533
Ammonia	205	487	1,622
Potash	664	664	664
Soda	554	554	554
Silica	36	5	8
Alumina	2	...	...
Oxide of iron	4	1	...
Oxide of manganese	1	...	...
Magnesia	36	22	30
Chlorine	272	272	272
Sulphuric acid	405	338	332
Phosphoric acid	70	26	46
Acetic acid	...	1	20
Sulphuretted hydrogen	...	1	30
Insoluble earthy phosphates and carbonates	...	180	150
Water	92,624	95,444	95,481
	100,000	100,000	100,000

These valuable experiments appear to bear directly upon the subject of the dry or wet preparation of manure, a subject which can hardly be too perseveringly and carefully examined. The whole process of the preparation of farm-yard manure, in fact, is full of interest to the farmer. The more carefully that we investigate the question, the more important does it appear, and the more numerous the sources of loss to be guarded against. For, as I have elsewhere remarked, nothing appears at first sight so simple as the manufacture and collection of farm-yard dung, and yet there are endless sources of error into which the cultivator is sure to fall if he is not ever vigilant in their management. The late Mr. Francis Blakie, in his valuable little tract upon the management of farm-yard manure, dwells upon several of them; he particularly condemns the practice " of keeping the dung arising from several descriptions of animals in separate heaps or departments, and applying them to the land without intermixture. It is customary," he adds, " to keep the fattening neat cattle in yards by themselves, and the manure thus produced is of good quality, because the excrement of such cattle is richer than that of lean ones. Fattening cattle are fed with oil-cake, corn, Swedish turnips, or some other rich food, and the refuse and waste of such food thrown about the yard increases the value of the manure; it also attracts the pigs to the yard; these rout the straw and dung about, in search of grains of corn, bits of Swedish turnips, and other food, by which means the manure in the yard becomes more intimately mixed, and is proportionately increased in value. The feeding troughs and cribs should, for obvious reasons, be shifted frequently. The horse-dung is usually thrown out at the stable doors, and there accumulates in large heaps. It is sometimes spread a little about, but more generally not at all, unless where necessary for the convenience of ingress and egress, or perhaps to allow the water to drain away from the stable

door. Horse-dung lying in such heaps very soon ferments, and heats to an excess; the centre of the heap is charred or burnt to a dry white substance, provincially termed *fire-fanged.* Dung in this state loses from 50 to 75 per cent. of its value. The diligent and attentive farmer will guard against such profligate waste of property by never allowing the dung to accumulate in any considerable quantity at the stable doors. The dung from the feeding hog-sties should also be carted, and spread about the store cattle yard in the same manner as the horse-dung."

To take the greatest advantage of the excreta of the live stock of a farm requires very considerable and persevering attention, not only in the farm yards, but in the bullock and sheep sheds—an attention but rarely bestowed. The young farmer, in general, needs no instruction as to the good policy of improving the *quality* of the farm manure by feeding his live stock on corn or cake; he will readily allow that the value of the manure thus prepared is increased to an extent equal to one-half of that of the oil cake employed; but of the importance of the *preservation* of the richest portion of it, after it is made, he is by no means so readily convinced. And yet he is well aware that the richest manure is that produced by stock in *sheltered* situations, in which the straw, to which the rain is denied access, is enabled to absorb a much larger proportion of urine than the wetter straw of the farm-yard. It is to this portion of the excreta of his stock that the attention of their owner is too seldom directed. It is not, in fact, generally remembered that the urine of a cow, for instance, far exceeds in weight that of its dung, and yet, from the very accurate experiments of Dr. Thomson, we find that while the average daily dung of a cow weighed only about 7¾ lbs., the urine during the same period weighed about 18 or 19 lbs. And it is a still more general and injurious delusion, that a given weight of dung contains a *much larger* proportion of enriching ingredients than the same weight of urine. In the dung of two cows, examined by Dr. Thomson, (*Farmer's Almanack*, vol. 3, p. 95,) were found about 86 and 96 per cent. of water. In the urine of the cow M. Sprengel (*ibid.* vol. 2, p. 95) found 92 per cent., or only two per cent. more than Dr. Thomson found in the dung. These experiments are proved to be practically correct by the results of other experiments upon their separate use as manure. Thus Professor Johnston (*Agric. Chemistry*, p. 170) has shown that, to produce the same effect as fertilizers, are required of cow *dung* 125 parts, but of its *urine* only 91; of horse *dung* 73, but of its *urine* only 16 parts; so that the *amount* is greater, and the *composition* of the ingredients of the urine of live stock is more fertilizing than that of the more solid excrement. I have already given the results of the experiments of Sprengel upon the composition of urine in different states of fermentation, and of the valuable mass of ammonia which is formed during the process. These results also lead me to consider the nature and extent of the ammoniacal matters, constantly arising in every shed and in every yard; and not only, let us remember, is the thus vapourising ammonia lost into the atmosphere, but it is in an equal degree with various rich organic matters running away in the drainage waters. That this drainage is less considerable from sheds and stables than from open yards is commonly true, since the rain water does not there swell the stream; but then the heat in covered buildings being greater, the formation of the salts of ammonia is more rapid, their vapourisation more copious. If the reader has any doubt of the existence of this state of affairs, let him be present when the door of a well-closed stable containing horses is first opened, after even a winter night, and he will be speedily assured of the fact—his nose

will give him abundant information. To accomplish any material saving in regard to the losses to which I have alluded, it will be necessary for the farmer to go systematically to work. In the case of stables and sheds, to prevent this loss of the richest portion of the manure, there are two substances which may be readily and profitably employed—gypsum (sulphate of lime) and charcoal. The first absorbs and decomposes the carbonate of ammonia, forming sulphate of ammonia, a valuable fertilizing salt, which is *not*, like the carbonate of ammonia, volatile; the second, charcoal, absorbs the salts of ammonia, and the other soluble matters of the farm-yard, and retains them unaltered for a considerable period. In either case it is only necessary to spread these substances as a foundation for the litter of the live stock in covered buildings, to prevent the recurrence of the serious loss to which we have alluded. Let those who are annoyed by the smell of stables have the gypsum powder carefully and systematically sprinkled on the floor of the stalls, and they will speedily be convinced of the power of the gypsum. A still better mode, when the *quantity* and *quality* of the *manure*, as in a farm, is an object, is to mix the gypsum with a considerable proportion of either charred peat, burnt clay, or any other substance containing a portion of charcoal; for by this plan the whole of the urine, of at least the *shed*-fed stock, is not only entirely preserved in the pores of the charcoal from putrefaction, but when carried on to the field it is *gradually* and steadily emitted, and becomes the food of growing crops. Of the use of charcoal as a fertilizer I shall hereafter have occasion to speak, and for these purposes an impure variety is profitably attainable, either in charred peat or refuse tanners' bark, or even in the charred matters of clay on moist farms. Whatever doubt there may exist of the value of charcoal, in its tolerably pure state, as a manure, there is I am convinced, from the result of my own trials and observations, none as to its value for the purpose of forming a bed on which the ordinary manure of animals is prepared.

THE DRAINAGE OF THE FARM-YARD*.

The amount of drainage which usually takes place from farm-yards may be commonly very much diminished by only a proper arrangement of eaves-troughs for the conveyance of the rain-water from the roofs of the barns and other outbuildings of the yard; and then, if the drainage still flows, there is either the tank and the water-cart to have recourse to, or it may be received and absorbed in a properly hollowed heap of earth, turf from the borders of fields, or best of all, of the earth to which I have alluded abounding in charcoal. It may be useful to the young farmer to remember that carefully *charred* peat ashes contain more than half their weight of charcoal; and that, if the peat is obtained from a *calcareous* district, it also commonly contains about ten per cent. of sulphate of lime (*gypsum*). (See *Brit. Husb.* vol. i. p. 336.)

The value of the drainage from a farm-yard or stable having been often doubted by practical farmers; the question has, in consequence, engaged the attention of some of the chemists of our time, who have so successfully addressed themselves to the study of agricultural chemistry. Dr. Davy has given, in the *Edinburgh Philosophical Journal*, a series of examinations of the drainage from dung-heaps in three different states; first, of the liquid draining from fresh stable dung immediately after a heavy fall of rain; the second, from a much larger and older dung-heap, after a fall of 1.12 inches of rain in 12 hours; a third specimen was ob-

* See "*British Husbandry*," *vol.* i., *p.* 266.

tained from the same dung-heap, after a fall of 2.79 inches of rain in 24 hours; and a fourth specimen from the same dung-heap, after four days of dry weather following the heavy rain last mentioned. "The bearing and application of these results hardly (concludes Dr. Davy) need pointing out. As the drainage of the dung-heap exposed to rain contains some of the best, the chief ingredients of active manure, it follows that the more the dung is exposed, the more it is subjected to the washing and percolation of rain water, the greater must be its loss, the poorer and the more exhausted it must become; and that shelter from rain is essential as a preventive—such a shelter as only can be well secured by a shed." (*See a very useful paper by Mr. T. Rowlandson, Quar. Jour. Agr.* 1845, p. 69.) These drainage matters of the dunghill have been still more closely examined by Professor J. F. Johnston (*Trans. High. Soc.* 1846, p. 187). A specimen, obtained from heaps of cow dung exposed to rain being examined, was found to be "dark coloured, and of course contained only what rain-water is capable of washing out of such dung-heaps. An imperial gallon of these drainings, when evaporated to dryness, left about 480 grains, or an ounce weight of dry solid matter. This solid matter consisted of—

"Ammonia	9.6 grains	
Organic matter	200.8	
Inorganic (Ash)	268.8	
		479.2

"The inorganic portion contained—

Alkaline salts	207.8 grains	
Phosphates of lime and magnesia	25.1	
Carbonate of lime (chalk)	18.2	
Carbonate of magnesia and loss	4.3	
Silica, and a little alumina	13.4	
		268.8

"Those therefore (concludes the Professor) who, besides allowing the urine of their byres to run to waste, permit the rain to wash their dunghills, suffer a double loss; they lose the ammonia-producing substances, and much alkaline matter in the urine and the phosphates, and a large additional portion of alkaline matter in the washings." It is pretty certain that in many situations the consideration and the application of these chemical researches may be used in the erections of the farm-yard with very considerable advantage to the cultivator; and that, moreover, in the preparation of manure in covered buildings, a still greater saving may be effected by previously covering the floor with dry absorbent substances, such as charcoal powder or burnt clay (which last is a mixture of dry earth with a portion of charcoal). "Wood charcoal," says the great chemist I have quoted so often, (and this quotation is an useful addition to my observations on charcoal as a fertilizer, in a subsequent page, see *post* p. 112,) "reduced to powder, charred sawdust, and charred peat, are all capable of being used with advantage in extracting the ammoniacal and other salts which give its value to the liquid of the farm-yards. Experiment has shown that, when filtered through a bed of such charcoal, the liquid escapes without colour and almost without taste, while the charred peat or sawdust is itself converted into fertilizing manure. Wherever, therefore, such charcoal can be obtained in abundance, and at little cost, by the practical farmer, this mode of employing it may be both useful and profitable to him." (*Trans. High. Soc.* 1846, p. 191.)

THE COMPARATIVE VALUE OF FARM-YARD MANURE PRODUCED UNDER DIFFERENT CIRCUMSTANCES *.

It has been long known that the manure produced by cake-fed animals is far superior in value to that of live stock fed on turnips, grass, or hay; and that the manure from stock fed in covered places is much more valuable than that yielded by the same animals, fed on the same food, but exposed to the impoverishing influence of the sun, rain, and the drainage of the open place in which they are confined. Considerable advance may be made towards a correct understanding of the *cause* of this very considerable difference, by an examination of some valuable recent comparative chemical examinations.

The ordinary and artificial food of live stock differs in composition, (and it is this which influences so materially the value of the excreta of animals,) in both its strictly organic and in its mere inorganic action. Thus, Dr. Thomson has shown that the proportion of oil and wax which is found in several varieties of food, and in the dung produced from it, is as follows (*Parl. Paper.* 1846):—

		Wax.	Oil.
Rye-grass		2.01	
Barley		...	2.18
Malt		...	1.37
Beanmeal		...	2.035
Linseed		...	4.00
Rye-grass	Hay	2.00	
Moist grass	Dung from	0.312	
Moist grass	Dung	0.600	
Dry grass	Dung	2.67	
Dry hay	Dung	3.82	

And again, if we contrast the composition of linseed cake with Swedish turnip, the superior amount of the oily and other fertilizing portions of the linseed cake is apparent. This will be readily seen by the analysis of both, which I will place in the same table. One hundred parts of Swede turnips and linseed cake contain, in their ordinary state, (*Trans. High. Soc.* 1845, p. 470; *ibid.* 1846, p. 202; *Johnson and Shaw's Farmer's Almanack*, 1847, p. 45):—

	Swede Turnip.	Linseed Cake.
Water	80.02	10.05
Oil	0.25	11.93
Sugar	5.37	
Mucilage } Acid of turnip and albumen } Albumen and gluten }	4.24	39.10 / 22.14
Woody fibre	1.22	9.53
Saline matter and ash	0.68	7.25

The saline or permanent portion of these, the ashes, are still more fertilizing in the linseed cake than in the turnip. Thus, while the ashes of the turnip grown in the ordinary way were found to contain 7.73 per cent. of phosphoric acid, those of linseed cake yielded 25.22 per cent.

And if we compare the inorganic ingredients which the turnips con-

* See "*British Husbandry,*" *vol. i. p.* 225—256.

tain, with those of linseed and of beans, (and whatever doubt we may entertain of the value of the *oily* or other organic portions of the food escaping into the dung, there can be no reason to doubt but the inorganic almost entirely serve to enrich the excreta of the animal,) the greater value of both the linseed and beans to the turnips is apparent. The ashes of 100 parts of each of these contain (*Farmer's Almanack*, vol. ii. p. 243; iii. p. 41):—

	Linseed.	Bean-meal	Turnips.
Silica	34.85	13.12	...
Phosphoric acid . . .	25.22	35.26	7.73
Sulphuric acid . . .	2.85	1.29	7.86
Chlorine	a trace	1.75	...
Lime	6.95	5.18	10.17
Peroxide of iron. . .	3.23	1.80	...
Magnesia	8.04	9.03	1.23
Potash	16.85	23.15	45.49 (Potash and Soda)
Soda	2.22	9.42	
Chloride of potassium .	...	...	9.72

Such, then, are the results of some of the chemical investigations which have been completed within the last year or two; experiments which pretty well show the truth of the conclusion of the farmers of England, that the manure produced by cake-fed stock is improved to an amount equal to half the value of the cake consumed.

The general opinion, in fact, has long been (and upon that the last generation of cultivators were content to base their calculations) the same as that of the Lincolnshire farmers, described by Mr. Williams, of Brocklesbury, that the use of oil-cake "has a most important effect in improving the quality of the manure, although there is seldom much profit to be made from it on the stock itself." That this is deemed by them not only material in amount, and not so limited in the duration of its effect, as some persons suppose, is evinced by the good custom which has recently been adopted in some portions of that county, of allowing the outgoing tenant half the value of the oil-cake consumed during the previous *two* years. "To get," says Mr. Williams, "a fair average as to both quantity and price, the allowance is made to extend over the two last years of the tenancy, and the allowance is *two-sixths* of the cake used in the last year, and *one-sixth* of that used in the previous one, making together the half of a year's consumption." (*Jour. R. Ag. Soc.* vol. vi. p. 45.) That the influence of oil-cake is not confined to the manure of *stall-fed stock* is quite certain. I have not only seen that this benefit is *immediately* evinced on all turnip soils by the cake-fed sheep, but I have in several instances, on the gravelly soils of Essex and Surrey, readily discerned those portions of the field so fed off by the superior luxuriance of the turnips produced *four years afterwards* on the same ground. That *grass land* is gradually and extensively benefited in a similar way, by the addition of cake to the stock feeding upon it, is perhaps not so generally understood. "A friend of mine," observes Mr. George Dobito, (*ibid.* p. 76,) "has lately adopted a plan which, under the same circumstances, I should strongly recommend. It is that of giving a small quantity of oil-cake to animals grazing, for the sake of improving an ordinary pasture, and its effects are astonishing. The pastures I allude to are small, and one or two bullocks more than they are calculated to carry are put into each. They are then allowed

each 4 lbs. of cake per day. This, at a weekly cost of about 2*s*. per head—which I believe the stock well paid for—has entirely altered the face of the pastures from what they were three years ago, when the plan was first adopted by him, and I believe without any loss to himself." "It is the abuse of stall feeding," he adds in another place, "that has got it into disrepute with some people, and the not treading straw enough down with others. This last I hold to be an advantage, instead of a disadvantage, for, depend upon it, it is not the *size* of the dunghill, but the *quality* of the manure, which causes the farmer's yard to be well filled." Mr. Main (*Jour. Ag.* 1846, p. 306) bears his valuable testimony to the great *permanence* of the manure produced from cake and stall-fed or sheltered animals. From some years' experience on a farm of 400 acres, he is able to prove, that the value of the manure "was clearly evident by the magnificent crops of turnips, barley, clover, and wheat which invariably followed its application; and I had the most convincing proofs in after years, that a coat of that feeding-house manure continued visibly serviceable to the crops for *nine years* afterwards." An attempt has been made (and the experiment was laboriously and carefully conducted) to determine the *amount of the benefit derived by the succeeding crop* from the use of linseed-cake by sheep, when feeding off turnips. The detail of a series of valuable experiments upon sheep-feeding has been given by Mr. Bruce, of Waughton, in East Lothian (*Trans. High. Soc.* 1846, p. 376). In one trial (commenced in January, 1844) 60 sheep were fed in three divisions of 20 each: division A had turnips and *home made* linseed cake; division B had turnips and *foreign* cake; and division C had turnips alone to the 1st of March. All three divisions were confined on adjoining portions of the same field. "Early in March," observes Mr. Bruce, "the land (the plots each contained 1.111 acres) was sown with wheat, reaped by the 20th of September, and thrashed on the 21st of December, when the produce of the different divisions (A and B having each consumed 1182 lbs. of cake) was found to be as follows, the grain being all properly cleared of refuse, but not separated into first and second quality:—

Lots.	Weight of grain.	Increase of Grain from Cake.	Weight of Straw.	Increase of Straw from Cake.
A	2248 lbs.	288 lbs.	3723 lbs.	817 lbs.
B	2223	263	3506	600
C	1960	...	2906	...

The gain, therefore, to the succeeding crop was considerable; and in estimating the expense, the farmer must remember that not only are the sheep increased in weight by the use of cake, (in Mr. Bruce's experiment the increase of division A *from the cake* was 209 lbs., and of division B 150 lbs.,) but that the amount of turnips consumed is most materially lessened; thus, in the above trials, sheep (division C) fed on turnips alone had consumed all their turnips by the 7th of February, but those fed on the same extent of turnips and oil-cake had not consumed their turnips until the 1st of March.

The chemical composition of farm-yard manure has been carefully examined. This consists of the straw of different plants, and of the solid and fluid excrements of cattle.

THE FÆCES OF CATTLE *.

The fæces of cattle fed principally on turnips have been analyzed by M. Einhof. 100 parts, evaporated to dryness, yielded $28\frac{1}{8}$ parts of solid matter; the $71\frac{7}{8}$ parts lost in drying would consist principally of water and some ammoniacal salts. In half a pound, or 3840 grains, he found 45 grains of sand; and by diffusing it through water he obtained about 600 grains of a yellow fibrous substance resembling that of plants, mixed with a very considerable quantity of slimy matter. By evaporating the fæces to dryness, and then burning it, he obtained an ash which contained, besides the sand, the following substances (*Johnson's Fertilizers*, p. 67):—

Lime	12
Phosphate of lime	12.5
Magnesia	2
Iron	5
Alumina, with some manganese	14
Silica	52
Muriate and sulphate of potash	1.2

Morin, a French chemist, observes Sprengel, (*Jour. R. A. S.* vol. i. p. 462,) afterwards investigated the solid excrements of cows which appear to have been fed on dry food: 1000 parts, by weight, consisted of the following substances:—

	Parts by weight.
Water	700
Vegetable fibre	241
A green fatty substance and resin (half decomposed green matter of leaves)	15
A yellowish sweetish substance, probably sugar of gall (picromel)	6
A brown shining substance	16
Coagulated albumen	4
Brown resinous substance (bilious resin)	18

The solid excrements of cows which appear to have been fed on green food were found, by the same chemist, to be composed as follows:—

	Parts by weight.
Water	712
Vegetable fibre	[illegible]
Green fatty substance	16
Sugar of gall	6
Brown shining substance	19
Coagulated albumen	7
Resinous substance	12

Zierl, also, has the merit of having subjected the solid excrements of cattle to a chemical analysis. According to him, animals fed on potatoes, beans, straw, and hay, gave excrements having the following composition:—

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* See "*British Husbandry, vol.* i. *p.* 227."

	Parts by weight.
Water	754
Sugar of gall and some soluble salts	11
Bilious and extractive matter	11
Deposited humus (starch?), with coagulated mucus and albumen	83
Vegetable fibre and remains of the food	141

1000 parts, by weight, of the dried excrements, when burnt, gave 60 parts, by weight, of ashes, which contained the following substances:—

	Parts by weight.
Silica	44
Carbonate and phosphate of lime	12
Carbonate, sulphate, and muriate of soda	2
Total	58

THE URINE OF CATTLE.

This, we have already seen, forms a very material portion of the fertilizing ingredients of farm-yard manure.

According to the analysis of Sprengel, (*Jour. R. A. S.* vol. i. p. 465,) 100,000 parts, by weight of the fresh urine of cows fed in a pasture abounding with good nourishing grass, several kinds of clover and vetch, a mixture of field fennel and plantain, much dandelion, hawkbit, and a great proportion of common daisy, were found to be composed as follows:—

		Parts by weight.
Water		92,624
Urea, along with some resinous colouring matter		4,000
Albumen		10
Mucus		190
Benzoic acid (hippuric acid)	Combined with potash, soda and ammonia, forming salts	90
Lactic acid		516
Carbonic acid		256
Ammonia		205
Potash		664
Soda		554
Sulphuric acid	Combined with soda, lime, and magnesia, forming salts	405
Phosphoric acid		70
Chlorine		272
Lime		65
Magnesia		36
Alumina		2
Oxide of iron		4
Oxide of manganese		1
Silica		36

THE FÆCES OF THE SHEEP *.

The dung of the sheep, proverbial for its enriching qualities, has been examined with considerable attention. The composition of this natu-

* See "*British Husbandry,*" *vol.* i. *p.* 227.

rally varies very considerably, both in the proportion of its solid contents and the chemical composition of the ingredients of which these, as well as its fluid portion, is composed.

According to Block, remarks Sprengel, (*Jour. R. A. S.* vol. i. p. 482,) there result from 100 lbs. of rye-straw given as fodder to sheep, 40 lbs. of excrements (fluid and solid); from 100 lbs. of hay, 42 lbs.; from 100 lbs. of potatoes, 13 lbs.; from 100 lbs. of green clover, 8½ lbs.; and from 100 lbs. of oats, 49 lbs. of dry excrement. In this case, therefore, the same thing happens as with cattle, upwards of one half of the solid food being lost, whether from straw or any other kind of food, (for 100 lbs. of green clover give 20 lbs. of hay, and 100 lbs. of potatoes leave 24 lbs. or 25 lbs. of solid substance,) partly in the formation of water, partly in the carbonic acid of respiration, partly in the production of wool and the formation of flesh and fat, and partly also in the last place, in the evolution of ammonia through the skin.

The solid excrements of the sheep have been chemically investigated by Zierl; and this, as far as I know, is the only chemical investigation we possess on the subject. One thousand parts, by weight, of the solid excrements of sheep fed on hay, contained—

Water	679
Sugar of gall and soluble salts (?)	34
Bilious, with extractive matter (?)	19
Humus, with coagulated albumen and mucus of the intestines	128
Woody fibre and vegetable remains	140

One thousand parts, by weight, of the dry excrement, gave on being burnt, 96 parts of ashes, consisting of—

Carbonate, sulphate, and muriate of soda	16
Carbonate and phosphate of lime	20
Silica	60

THE URINE OF THE SHEEP.

The urine of the sheep has been recently analyzed by Mr. Fromberg, under the direction of Professor J. F. Johnston, (*Trans. High. Soc.* 1846, p. 309,) and these researches are fraught with interest to the farmer. The urine of different animals varies in fact very materially in composition. "The urine of omnivorous animals," remarks Professor Johnston, "such as that of man, and of the pig, contains phosphoric acid, in combination with lime and magnesia; but that of herbaceous animals in general is destitute of this important food of plants. The ox and the horse discharge the whole of the phosphates contained in their food along with their solid excretions, so that their urine contains none, and the *hare* is the only herbivorous animal yet known, in the urine of which these phosphates have hitherto been found in considerable quantity." Ten gallons of the urine of the sheep contain 7 lbs. of dry fertilizing matter. The dry matter comprised, in 100 parts (*Farmer's Almanack,* vol. iii. p. 23):—

Dry organic matter, containing nitrogen	71.86
Inorganic or saline matter	28.14

The saline matter or ash contained, in 100 parts—

Sulphate of potash	2.98
„ soda	7.72
Chloride of potassium	12.0

Chloride of sodium	32.01
Carbonate of soda	42.25
„ lime	0.82
„ magnesia	0.46
Phosphates of lime, magnesia, and iron	0.70
Silica	1.06

The urine of the sheep, therefore, observes Mr. Johnston, contains only a very small quantity of phosphoric acid in combination with lime and magnesia. It agrees very closely in this respect with that of the ox and the horse, in which no trace of phosphate has yet been detected. It abounds also, like the urine of these animals, in salts of potash and soda. It is especially rich in common salt, and in soda, which in the ash is in the state of carbonate, but which in the urine is no doubt combined with some organic acid. If it be natural to the urine of healthy sheep to contain so much soda, we may find in this one reason why they relish salt so highly, and thrive so much better when it is abundantly supplied to them. The organic portion of the urine contains in 1000 parts—

Water	928.97
Urea	12.62
Organic matter soluble in alcohol	33.30
Organic matter soluble in water, insoluble in alcohol	3.40
Organic matter soluble in weak potash, insoluble in water and alcohol	0.10
Organic matter insoluble in any of these liquids	01.5

Inorganic matter, consisting of—

Sulphate of potash	0.51	
„ soda	1.32	
Chloride of potassium	2.05	
Common salt	5.47	
Sal ammoniac	3.00	
Chalk	0.14	20.09
Carbonate of soda	7.22	
„ magnesia	0.08	
Phosphate of lime and magnesia, with a trace of phosphate of iron	0.12	
Silica, with a trace of oxide of iron	0.18	

THE FÆCES OF THE HORSE*.

The same remarks which I have already made, as to the varying quality and quantity of the excreta of cattle and sheep, apply to those of the horse.

According to Block, (*Jour. R. A. S.* vol. i. p. 489,) 100 lbs. of chopped rye-straw, given as fodder to horses, yield 42 lbs.; 100 lbs. of hay, 45 lbs.; 100 lbs. of oats, 51 lbs.; and 100 lbs. of rye, 53 lbs. of dried excrements (fluid and solid). The solid excrements of the horse have been subjected to chemical investigation. According to Zierl, 1000 parts by weight of the solid excrements of horses fed on hay, oats, and straw, contain—

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* See "*British Husbandry*," *vol.* i. *p.* 226.

Water	698
Picromel and soluble salts (?)	20
Bilious and extractive matter (?)	17
Green humous matter with coagulated albumen and intestinal mucus	63
Vegetable fibre and remains of food	202

One thousand parts by weight of the dried solid excrements gave, on burning, according to Zierl, 60 parts by weight of ashes, of the following composition:—

Carbonate, sulphate, and muriate of soda	5
Carbonate and phosphate of lime	9
Silica	46

THE URINE OF THE HORSE.

The urine of the horse contains in 100 parts, according to the analysis of MM. Fourcroy and Vauquelin, (*Thomson*, vol. iv. p. 348,)

Water	94.0
Urea	0.7
Benzoate of soda	2.4
Carbonate of soda	0.9
Carbonate of lime	1.1
Muriate of potash	0.9

THE EXCREMENTS OF THE PIG*.

I am not aware of any chemical examination of the fæces of the pig; but being, as Sprengel remarks, of all animals the most indiscriminate in their diet, their excrement must on that account vary very materially in composition, according to the kind of food they may happen to obtain. Of all animals, the pig discharges the largest quantity of urine; this, according to Sprengel's analysis, contained in 100 parts of a specimen obtained from pigs fed on corn offal. (*Jour. R. A. S.* vol. i. p. 492):—

Water	92.600
Urea, with a very little mucus, albumen, and colouring matter	5.640
Salts; as common salt, muriate of potash, gypsum, carbonate of lime, and sulphate of soda	1.760

THE EXCREMENT OF BIRDS.

The only excrement of birds which has to any extent been available in agriculture, (besides guano, which will require a separate notice,) is that of pigeons, of whose use, as a fertilizer, by the early cultivators of the earth, there is abundant evidence. In Belgium, according to Sprengel, (*Jour. R. A. S.* vol. i. p. 494,) it is employed to a considerable extent, and particularly for manuring their flax. The Belgian farmer calculates the annual value of 400 or 500 pigeons to be equal to 25 or 30 rix dollars, (about 5*l.* or 6*l.*) It is also carefully collected in Egypt, and has been even recently imported from thence into England. This has been analyzed by Professor Johnston (*Trans. High. Soc.* 1847, p. 580); he found it to be composed of—

* See "*British Husbandry*," *vol.* i. *p.* 228.

Water	6.65
Organic matter, containing 3.27 per cent. of nitrogen, equal to 3.96 of ammonia	59.60
Ammonia	1.40
Alkaline salts	0.42
Phosphates of lime and magnesia	7.98
Carbonate of lime	2.37
Insoluble silicious matter	21.42
	100.00

THE USES OF CHARCOAL AS A MANURE.

In speaking of the means of preventing the loss in farm-yard manure which arises in its ordinary mode of preparation, from its drainage and the rapid decomposition of its most valuable portion, (see *ante*, p. 108,) I had occasion to allude to the use of charcoal. This substance, the carbon of the chemist, possesses very considerable power in the absorption of gaseous and other fluid matters, and is, as obtained in its impure varieties after the charring of peat, turf, &c., a very valuable and pretty easily procurable agent in the hands of the skilful farmer. As I have elsewhere had occasion to remark, in a valuable agricultural periodical, (*Farmer's Magazine*, vol. xxiv. p. 387,) it is always instructive to examine the generally slow progress by which any agricultural improvement is accomplished, a new manure established in the farmer's list, or a new agricultural practice or implement introduced. The remark well applies to the use of charcoal as a fertilizer; and we need hardly feel surprised at this, when we remember that the charcoal of commerce, as commonly procured by the slow and only partial combustion of small forest wood, is generally too valuable for other purposes, to be employed by the farmer as a dressing for his land. It is true that in many places the charcoal of peat may be obtained at a sufficiently reasonable rate; but the farmers who formerly dwelt in the neighbourhood of the great fens and bogs of the United Kingdom were, perhaps, but little acquainted with the distinction between the charcoal of peat and turf, and the *ashes*, or mere earthy or saline matters remaining after the complete combustion of those substances had taken place. I propose to examine this difference, and the mode, as far as our present chemical knowledge extends, in which the charcoal so beneficially operates upon vegetation; and I do this with the hope that the preparation of turf charcoal may not only be found a very remunerative operation to the farmer, but afford very considerable and profitable labour to the unemployed poor.

The distinction between *charring* peat and *burning it to an ash*, was pointed out 259 years since, by one of the earliest of the English agricultural writers; and considering the limited chemical knowledge of his days, he did not, as far, at least, as the presence and operation of the two salts (sulphate of lime and phosphate of lime) of peat ashes are concerned, arrive at a very wide approach to the truth in his explanation of the cause of their fertilizing effects. "Ashes," says Worlidge, who wrote in 1697, (*Mysterie of Husbandrie*, 72,) "contain in them very much of a rich and fertile salt; the wood ashes are the best, and very useful. Turf and peat ashes must needs be very rich, being much after the same manner as the burning of land."

Worlidge, however, was far from being the first who noticed the use of charcoal and wood ashes. Cato recommends the burning of the twigs and branches of trees, and spreading them on the land. This appears

to have been an ancient practice in Lombardy, for in 1570 Conradus Heresbachius, in his treatise on "Husbandrie," translated by Googe, tells us, (p. 20,) that "in Lombardie they like so well the use of ashes, as they esteem it farre above any doung." From the days of Worlidge down to the end of the seventeenth century, hardly an agricultural writer appeared who did not to some extent or other advocate the use of charcoal as a dressing for land.

In April, 1783, Arthur Young commenced a series of experiments, not only with charcoal, but with sulphuric acid, and a variety of other substances as manures. The experimental researches of this celebrated agriculturist were much too commonly conducted on so small a scale as materially to detract from their value; but still, notwithstanding this drawback to their practical use, the very numerous trials dispersed throughout the early volumes of his "Annals of Agriculture" abound with proofs of the sagacious reasoning and love of truth which distinguished Arthur Young. The trials with charcoal are given in the "Annals," p. 139 of vol. i. It is needless to closely follow these garden-pot experiments; the conclusions, however, observed Young, (p. 149,) were that "charcoal contains something that assists vegetation for a time considerably. To what then is the benefit owing? Are we to consider charcoal as a body not differing from wood ashes? This trial, combined with the results of others, will not allow such a conclusion, for I have found those ashes to *act in proportion to the goodness of the soil;* to do little good on poor land, but we find the effect of charcoal considerable for a time." Again he adds, (p. 153,) "charcoal alone has done good in one instance from first to last." Young adds, (p. 162,) with his usual love of accurate detail and truth, when speaking of one of his series of experimental pots—"A carpenter letting a piece of timber fall on the pots, while putting up a bench, broke some and tumbled the rest over; here, therefore, ends this trial." He seemed, indeed, ever to feel, as he remarked on another occasion, (*ibid.* p. 188,) that "the man who wants this sort of candour is fit only for voluntary ignorance."

In 1826 a very excellent volume upon peat, moss, or turf-bog, appeared by Mr. Andrew Steele, of Crosswoodhill. He says, (p. 33,) "Firm peat is very easily charred by smothered combustion, even in an ordinary fire-grate, as is generally done in Holland, where its charcoal is commonly used in winter for burning in small pots for the purpose of keeping the feet warm. We are informed by Mr. Headrick, that some of the Scotch Highlanders convert large quantities of black peat into charcoal, which the smiths use in their forges; and he thinks this species of fuel is better adapted for the reduction of metal, and the making of bar iron, than even charcoal of wood." When speaking of the various modes of preparing peat charcoal, Mr. Steele adds, (p. 357,) "Two methods have been followed in these trials, the one by exposing the peat to a smothering heat, as is practised in the making of charcoal from wood; the other by exposing it to a heat in close vessels or furnaces, and thus subjecting it to a kind of distillation."

In 1846, Mr. C. E. Rogers drew the attention of the public to the importance of turf or peat charcoal as a manure, and as affording abundance of remunerative employment to the unemployed poor of Ireland. After this publication, the Royal Agricultural Society of England offered a premium of twenty sovereigns for the best essay on peat charcoal as a manure. And soon after Mr. Rogers published another work on the same important subject, and especially on the value of turf charcoal to the iron manufacturers, which I recommend to the early notice of the

Irish landowners and farmers. In this work he adds his testimony to the value of turf charcoal as a fertilizer, and attributes its influence, as a manure, to its powers (amongst other good properties) of absorbing the excretory matters which plants deposit in the soil*.

The chemical operation of charcoal, when employed for this purpose, is by no means, however, so well understood as that of most other fertilizing additions to the land. That plants derive their supply of carbon from those gases, such as the carbonic acid gas, of which carbon forms the base, is not only the opinion of Liebig and Johnston, but of all the enlightened chemists of our day. That the carbon of the charcoal operates so beneficially upon plants, amongst other modes, by a gradual combination with oxygen, hardly admits of a doubt. Liebig gives the results of a series of experiments by Lukas, on the use of charcoal as a manure, which seem to corroborate this opinion. From the facts which these chemists, however, adduce, it is evident that the beneficial action of charcoal, as a fertilizer, depends upon the presence of other substances besides carbon. Liebig notes (*Organic Chem.* p. 62) that "plants thrive in powdered charcoal, and may be brought to blossom, and bear fruit, *if* exposed to the influence of the rain and the atmosphere. Plants do not, however, attain maturity under ordinary circumstances, in charcoal powder, when they are moistened with *pure distilled water* instead of rain or river water. Rain water must therefore contain within it one of the essentials of vegetable life; and it will be shown that this is the presence of a compound containing nitrogen: the exclusion of which entirely deprives humus and charcoal of their influence upon vegetation." It is ammonia, to whose presence in rain-water Professor Liebig thus refers, in whose valuable work (p. 207) the experiments of Lukas will be found. From these we learn that in a division of a low hothouse, in the Botanical Garden at Munich, a bed was set apart for young tropical plants; but instead of being filled with tan, as is usually the case, it was filled with powdered charcoal, the large pieces of charcoal having been previously separated by means of a sieve. The heat was conducted by means of a tube of white iron into a hollow space in this bed, and distributed a gentle warmth, sufficient to have caused tan to enter into a state of fermentation. The plants placed in this bed of charcoal quickly vegetated and acquired a healthy appearance. As always is the case in such beds, the roots of many of the plants penetrated through the holes in the bottom of the pots, and then spread themselves out; but these plants evidently surpassed in vigour and general luxuriance plants grown in the common way, for example in tan."

M. Lukas then gives a list of several of the exotic plants upon which charcoal appears to have produced the most beneficial effects. It appeared also to promote the rapid germination of seeds. He then proceeded to try the effects of charcoal when mixed with vegetable mould, all of which answered very well. "The charcoal," continues M. Lukas, "used in these experiments was the dust-like powder of charcoal from firs and pines. *It was found to have most effect when allowed to lie during the winter exposed to the action of the air.* In order to ascertain the effects of different kinds of charcoal, experiments were also made upon that obtained from the hard woods and peat, and also

* *Letter to the Landlords and Ratepayers of Ireland; detailing means for the permanent* and profitable employment of the peasantry without ultimate cost to the land or the nation, and *within the provisions of the* Act 10 Vict. c. 107. By Jaspar W. Rogers, C.E. London: J. Ridgway.

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upon animal charcoal; although I foresaw the probability that none of them could answer so well as that of pinewood, both on account of its porosity and the ease with which it is decomposed. The action of charcoal consists primarily in its preserving the parts of plants with which it is in contact, whether they be roots, branches, leaves, &c., unchanged in their vital power for a long space of time, so that the plant obtains time to develop the organs for its further support and propagation. There can scarcely be a doubt also that the charcoal undergoes decomposition, for after being used five or six years it becomes a coaly earth. It exercises likewise a favourable influence by absorbing and decomposing the matters excreted by the roots of plants, so as to keep the soil free from the putrefying substances, which are often the cause of the death of the *spongiolæ*." "Every experiment," concludes M. Lukas, "was crowned with success, although plants belonging to a great many different families were subjected to trial." (*Ibid.* p. 211.)

Professor J. F. Johnston (*Elem. of Ag. Chem.* p. 142) recognises the good properties of charcoal as "a valuable mixture with liquid manure, night-soil, farm-yard manure, ammoniacal liquor, or other rich applications to the soil." And, as he observes in another place, when speaking of the fertilizing portions of farm-yard drainage, (*Trans. High. Soc.* 1846, p. 190,) "The only substance at present known, by which the separation of all the valuable ingredients from liquid manure can be fully effected, is *animal* charcoal. A sufficient supply of this substance, when intimately mixed with the liquid manure, will take up nearly the whole of the saline and colouring matters it holds in solution, will carry down the substances it holds in suspension, and will leave the water nearly pure and colourless. The refuse of the prussiate of potash manufactories will have this effect, and what remains when ivory-black is digested in spirit of salt, (muriatic acid,) will do still better; but this kind of charcoal is neither cheap nor abundant, and, therefore, cannot be recommended to general use. The refuse animal charcoal of our manufactories is now sold for manure at the price of several pounds a ton: either those who sell it, or those who use it, might render it still more valuable, by causing fermenting liquid manure to filter through it before it is applied to the land.

"But other kinds of charcoal possess this property to a certain extent: wood charcoal, reduced to powder, charred sawdust, and charred peat, are all capable of being used with advantage in extracting the ammoniacal and other salts, which give its value to the liquid of our farm-yards. Experiment has shown that when filtered through a bed of such charcoal, the liquid escapes without colour, and almost without taste, while the charred peat or sawdust is converted into fertilizing manure. A great portion of the loss now incurred may be prevented by the use of such kinds of charcoal, and the fertilizing substance may, through their means, be applied to our crops, at seasons of the year for which, in their liquid form, they are not suited. It is even capable itself of yielding *slow* supplies of nourishment to plants; and it is said in many cases, even when unmixed, to be used with advantage as a top dressing In moist charcoal the seeds of the gardener are found to sprout with remarkable quickness and certainty, but after they have sprouted they do not continue to grow well in charcoal alone. Drilled in with the seed, charcoal powder is said greatly to promote the growth of wheat."

As it is of great importance that the farmer should understand the difference between turf and peat *charcoal*, and the *ashes* of these substances, I will here repeat what I have elsewhere had recently occasion

peat is reduced in weight and bulk considerably by charring. Peat loses about three-fourths of its weight by being dried in sun and winds. By charring, peat is reduced to one-fourth of its previous *bulk*, and the charred peat, by burning to ashes, is reduced to one-half its bulk."

The *quantity* used per acre will of course, as Mr. Raynbird remarks, vary with the circumstances of the crop; when drilled in rows, with or without the addition of other artificial manure, the quantity need not exceed from 20 to 40 bushels per acre; when drilled broadcast, from 100 to 150 bushels per acre will not be a very expensive dressing.

From some experiments of Lord Essex, (*ibid.* p. 280,) it would seem that in dry seasons powdered charcoal mixed with nine and twelve times the bulk of the drilled seed of both Swede turnips and carrots, materially promoted their germination. The proportion he used, however, may be beneficially increased. This property of charcoal is confirmed by Mr. Raynbird of Hengrave, (*ibid.* vol. vii. p. 543,) as regards carrot seed; and when in a subsequent page, speaking of turnips, he adds, "on July 2, 1844, 48 bushels per acre of peat charcoal were drilled with green-topped Aberdeen turnips on a light sandy loam, the previous crop being rye and vetches mown for soiling. The young plants appeared above ground in a short space of time, and were singled out in a week, as soon as turnips of a quicker growing kind that had been drilled twelve days earlier with $1\frac{1}{2}$ cwt. of guano, mixed with peat ashes, per acre. This was on the same description of soil, the previous crop being rye fed off with sheep, and the land being then manured with 15 cart-loads per acre of farm-yard dung; the other, in addition to the charcoal, had been folded. The crops were good, but the cost of the peat charcoal was barely one-half that of the guano, without taking into consideration the extra dressing of farm-yard manure." I hardly deem it necessary to prove further, by the evidence of farmers, the value of charcoal as a valuable manure; and if it was necessary to obviate the suspicion that there is any difference in the effect produced by the use of charcoal ashes and the impure variety of these ashes afforded by peat, I am readily supplied with the means of doing so by a recent report by Mr. Peter Mackenzie, of West Plean, near Stirling. (*Quar. Jour. of Agric.* 1846, p. 467.) He tells us that he has been for some years past trying experiments with peat, *charred* peat, and peat ashes, as a substitute for stable manure, and for many kinds of crop grown by farmers and gardeners. He remarks, "In the spring of last year I collected a quantity of peat for various purposes, and part of it was intended to be charred or burned. It was not so well prepared for burning as I wished, a good deal of moisture being in it; however, a good fire was made of wood to begin with and as the peat dried it was drawn to the fire, and in this way was kept burning for two weeks. It required little watching, only once or twice in twelve hours. The partially dried peat was drawn to the fire, because it was intended to have a quantity of *charred* peat and ashes mixed together, and, in order to obtain both, the fire was kept in a smothered state to *char* the peat, (let the farmer mark the distinction). It commonly burst through in some parts, and there supplied the ashes. When we had a quantity to begin with, the unburnt peat and the charred, with the ashes, were all well mixed together; at least one-half of the mass was unburnt peat." This mixture was applied about the beginning of May, to a light sandy soil, for a crop of Swedish turnips. The quantity used was at least at the rate of 200 bushels per acre. "We tried it," continues Mr. Mackenzie, "against well-made stable-manure in a state like mould, cut well with

the spade, which was applied at the rate of about 20 tons to the acre, and spread into drills, like the peaty mixture. The plants grew well in both cases. We tried to ascertain the amount of produce per acre from each manure, as late as the middle of January, 1846; for, from the mildness of the season, the turnips till then appeared to be in a growing state, each plant having had about two square feet of surface to grow upon. The surface was kept flat, and the ground chiefly worked with the Dutch hoe. The weight of bulbs fit for use manured with the peaty mixture was upwards of 40 tons per acre; while those produced from stable-dung weighed only about 30 tons. One row of peas was also manured with the peaty composition, and yielded as great a crop as those manured with the stable-manure." Such a preparation of charcoal, although mixed with other substances, the farmer, as I have already observed, will find very valuable in a variety of ways. It would constitute an excellent foundation for dung-heaps or sheep-folds, since charcoal very extensively absorbs the gaseous matters of putrefaction, and, when used in considerable proportions, would also imbibe all the drainage matters of the sheep, or other live stock. It answers as well, also, for a *covering* for dunghills; but to this end, again let me remind the farmer, that he must only *carbonise* or *char* his peat or turf; he must, to accomplish this, by covering the burning heap with earth or green turf, retard, regulate, and reduce the extent of the combustion as much as possible. It is to the presence of a considerable portion of carbon in the ashes of land pared and burnt, that the advantages of this nearly exploded operation may be chiefly attributed. The ashes of a pared and burnt chalk soil from Kent contained four to five per cent. of carbon, that of a light Leicestershire soil contained six per cent., and that of a stiff clay soil from Mount's Bay, in Cornwall, contained eight per cent. of carbon.

THE MANURES COMPOSED CHIEFLY OF THE PHOSPHATE OF LIME*.

It is only of late years that more correct views have been entertained of the action of the important class of fertilizers whose chief ingredient is the phosphate of lime. This class includes crushed bones, superphosphate of lime, and the native or phosphate of lime, the apatite, &c., of the mineralogist. It is to the researches of the chemist that we are indebted for our very material increase of knowledge on this head. The early employer of bones naturally enough attributed their beneficial effect to the *grease* which they contained, and when it was found, after the chief portion of this fatty matter had been removed by the bone-boilers in various manufactories, the bones still answered as well as ever for a manure—even this discovery only made the crushed bone users cling with great tenacity to the remaining portion of the grease. In a work published twenty-five years ago, (*On the Use of Bones as a Manure*, p. 4; see, also, *On Fertilizers*, p. 137,) having occasion to refer to the subject, I observed,—" There is yet another source from whence the phosphate of lime might be obtained in large quantities for the use of the farmer, viz., the fossil bones, or native phosphate of lime, which is found in various districts of this country, in very considerable quantities, and would only require crushing or powdering to render it nearly as useful to the farmer as the recent bones; for, that the cartilage or oily matter of the bone does not constitute the chief fertilizing quality, is shown by the fact, that the farmers who use bone dust will as readily employ that which

* *Supplementary note for Vol. 1, p. 405.*

has first been used, and all its fatty portion extracted by the preparers of cart-grease, as they will the unused fresh bones*. The mineral substance called the apatite, found in the Cornish tin mines, is nothing but phosphate of lime; 100 parts being composed of—

Phosphoric acid	45
Lime	55

"The phosphate of lime is also found in many parts of the north of England, in Hungary, and in immense beds in Spanish Estremadura, where it is said to be so common in many places, that the peasants make their walls and fences of it. 100 parts of this substance, called by mineralogists the phosphorite, contain—

Phosphoric acid and lime	93 parts
Carbonate acid	1
Muriatic acid	0.5
Fluoric acid	2.5
Silica	2
Oxide of iron	1

The inquiry as to the quantity in which this native phosphate of Spain exists having engaged the attention of the Royal Agricultural Society of England, Dr. Daubeny and Captain Widdrington were induced, in 1845, to make a voyage into Spain to examine it, and they have since published the result of their inquiries. (*Jour. R. A. S.*, vol. v. p. 406.) They found the phosphorite rock existing in large masses, a short distance from Logroson, a considerable village, about seven Spanish leagues to the south-east of Truxillo, in Estremadura. It forms "a rock varying from 7 to 16 feet in breadth, traceable for nearly two miles along the ground, and extending into the earth to a great, though as yet an unascertained, depth." Some specimens, analyzed by these highly usefully employed voyagers, consisted, per cent. of—

Silica	1.70
Peroxide of iron	3.15
Fluoride of calcium (fluor spar)	14.0
Phosphate of lime	81.15

They brought with them to England a sufficient supply of the phosphorite to enable its agricultural powers to be ascertained by various trials; some of these experiments were made by Dr. Daubeny, on turnips, with the following results (*Jour. R. A. S.*, vol. vi. p. 330):—

	Roots.	Tops.
Soil, simple, produced per acre	14,298 lbs.	30,591 lbs.
——manured with 10 cwt. of bone shavings per acre	19,239	35,210
——Spanish phosphorite alone, 12 cwt.	28,639	42,016

* "It is acknowledged by our correspondents to be a prevalent opinion, amongst intelligent farmers, that manufactured bones are equal, in their effects, to the raw bones. Mr. Shott, in the year 1812, 'Boned twenty-four acres, at the rate of fifty bushels an acre. On one part of the field he put London bones, which had the oil stewed out of them; and another part was tilled with bones collected from Nottingham, which were full of marrow, and a third part with horses' bones, having much flesh upon them. He could not see any difference in the turnips produced from these; they all produced a good crop. But the next crop was not so good, where the fleshy bones had been laid.' And Mr. Horncastle adds, 'A strong fermentation takes place in the boiled bones: when thrown in a heap, they become extremely offensive, and when they obtain this bad smell, I consider they are in a state to break up for manure.'"—*Doncaster Ag. Soc. Rep.*

	Roots.	Tops.
Soil, Spanish phosphorite, 12 cwt., mixed with sulphuric acid	30,869 lbs.	34,476 lbs.
——South American guano, 260 lbs.	31,114	47,060
——bones, with sulphuric acid, 11 cwt.	31,898	17,600
——bones, finely powdered, 12 cwt.	36,185	45,446
——stable dung, 22 tons	39,476	49,912

The conclusion to which these experiments tend is, as Dr. Daubeny well remarks, that "as the Spanish phosphorite, which appears to act so beneficially, is wholly destitute of organic matter, it seems to follow that the more valuable portion at least of what is applied to the land, when bones are scattered over it, is the phosphate of lime, and not, as some have supposed, the oil or gelatine."

The conclusion to which we are thus led is supported by the experiments of Sir Harry Verney on the use of the phosphorite as a manure. The soil to which he applied it was a heavy sandy loam, resting on a clayey subsoil; the ground was sown with mangel wurzel in 1844, whose seeds, through the extreme drought of the summer, did not vegetate sufficiently for any satisfactory result to be obtained. In April, 1845, the ground was sown with Chevalier barley, with the following result (*Jour. R. A. S.*, vol. vi. p. 333):—

	Manure per acre.			Produce.		
	tons.	cwt.	qrs.	qrs.	bush.	pks.
Soil, simple	0	0	0	3	6	2
Burnt bones	0	18	0	5	3	2
Unburnt bones	1	7	0	5	0	0
Pigeons' dung	0	18	0	7	5	0
Spanish phosphorite and sulphuric acid	0	18	0	6	3	2
Spanish phosphorite alone	0	18	0	5	3	2
Super-phosphate of lime	1	5	3	5	6	3
Stable-yard dung	20	0	0	8	2	0

The very successful use of the super-phosphate of lime, of which, in a subsequent page, I shall have occasion to speak still further, supports the conclusion, that the removal of the animal matters from the bones does not impair their fertilizing powers; for in these operations of preparing the super-phosphate, although a considerable portion of the grease, cartilage, &c., of the bones, is decomposed or carbonized by the action of the sulphuric acid, the action of the super-phosphate of lime is fully equal to that of the undecomposed bones. Another mode of showing the value of the phosphate of lime of these fertilizers, is by inquiring if there is any considerable portion of phosphate of lime annually removed from the soil of a farm by its crops or its live stock, which the manure of the farm-yard or the excreta of the live stock do not to an equal extent restore to it; since it is evident that if by the result of our inquiries we ascertain that there is any essential constituent of the soil which is thus permanently separated from the farm, then, if we wish to preserve only the fertility of the land, we can have remaining to us only one practical inquiry; viz., How is this salt to be the most economically and beneficially restored to the land? Now we find that the phosphate of lime not only exists as an essential constituent in almost every cultivated crop, but in still larger proportion in the bones of all animals; in every farm, therefore, as I have elsewhere remarked, (*Bell's Messenger*, 1846, p. 85,) this salt is constantly removing from the soil, not only in all the corn which its holder sends to the mar-

ket, but in every growing animal he parts with. This salt being composed of phosphoric acid 59 parts, and lime 47 parts, the statement of the proportion of phosphoric acid which the seed contains affords a pretty accurate statement of the corresponding proportion of the phosphate of lime, since the other phosphates, those of magnesia, potash, or soda, are less extensively found in the ordinary plants of the farmer. The proportions in which the phosphoric acid exists in 10,000 lbs. weight of various farm products, has been ascertained by a celebrated German chemist in Spruegel, and some of the results he obtained may be very useful to the farmer, placed in the following easily formed table. (*Farmers' Almanac*, vol. iii. p. 63.) We may divide these into two classes; first, those crops very commonly carried off the farm; and, secondly, those generally consumed on the land.

1. Seeds not generally consumed on the land—

10,000 lbs. of the	Seeds of wheat	contain	of phosphoric acid	400 lbs.
„	Seeds of barley	„	„	210
„	Seeds of oats	„	„	70
„	Seeds of beans	„	„	292
„	Seeds of peas	„	„	190

2. The straw and roots chiefly consumed on the land, and whose solid constituents are returned to the soil:—

10,000 lbs. of the	Straw of wheat	contain	of phosphoric acid	170 lbs.
„	Straw of barley	„	„	160
„	Straw of oats	„	„	12
„	Straw of beans	„	„	226
„	Straw of peas	„	„	240
„	Red clover	„	„	138
„	Sainfoin	„	„	220
„	Cabbages	„	„	436
„	Common turnips	„	„	73
„	Swede turnips	„	„	408
„	Carrots	„	„	395

From these results the farmer will readily perceive how considerable a proportion of this salt, so essential to the prosperity of his crops and his live stock, is constantly drawn from the soil by his ripening corn; and in classing as I have done the crops of the farm, I have included in the list of home consumed products several which are very commonly removed from the farm and used elsewhere. The extent of the demands made upon the soil for this salt by growing animals has been estimated by Mr. Hayward (*ibid.* p. 95). He calculates that the amount of phosphoric acid annually carried away by the live stock, from a farm of 100 acres, to be equal to 413 lbs., or 1491 lbs. of bones. His estimate is as follows:—

	Acid.	Bones.
In the bones and flesh of 110 lambs, of 25 lbs. each, at 6 weeks old	145	537
In 40 year-old sheep, of 90 lbs. each	210	777
In 4 calves, at 5 weeks old, weighing together 500 lbs.	21	77
In 4 young cows, forming 135 lbs. of flesh and 35 lbs. of bone each per annum	16	23
In 2 young horses, gaining the same as the last.	21	77

The removal of this phosphate of lime from the soil being thus clearly ascertained, the last part of the inquiry only remains—Is the restoration

of this salt to the land productive of fertilizing effects? Are the plants dressed with manures in which it forms a chief constituent found to absorb an increased proportion of it? And if we receive an affirmative reply to these questions, then how is the substance to be procured as a dressing to the soil in the most practically useful way? The chief modes in which the farmer has long been accustomed unconsciously to return this salt to the soil has been, by the use of oil cake for his stock and of crushed bones for manure. In a more recent period the use of guano, of urate, &c., has been in fact a similar operation. It has been found by Professor Johnston, (*Trans. High. Soc.* 1845, p. 470,) that turnips grown upon land dressed with guano contained a considerably larger proportion of phosphate of lime than the turnips grown in the adjoining soil, dressed in the ordinary way, the ashes of the turnips grown with the ordinary farm-yard dung containing 7.73 per cent. of phosphoric acid, whilst the turnips produced on the land manured with guano yielded 19.39 per cent. (we shall presently see that guano abounds with the phosphate of lime.) There is no reason to doubt but that the effect of dressing turnips and several other crops with oil cake and crushed bones is to increase their proportion of phosphate of lime. We see in the instance of land whose green crops have been fed off by sheep, whose food has been varied, that the portions of the field on which they had oil-cake given to them becomes considerably more fertile than those portions on which the stock had to subsist on only the green crop of the field. Every farmer is aware, too, that on many soils this superior fertility of the cake-fed portions is apparent to a remarkable degree in the succeeding crops for several years. That it is not to the portion of *oil*, or other purely organic matter of the linseed cake, that this increased and lengthened fertility of the soil is to be attributed, we may safely conclude, when we remember that the beneficial *duration of oils* in the soils, and of all those manures, such as whale blubber or sprats, in which the *oil* is the chief fertilizing ingredient, is almost invariably confined to a single crop; and, moreover, the proportion of fatty matters in linseed cake is very small (and that amount too, after it has been consumed by the animal, must be materially diminished). In three specimens of linseed cake analysed by Mr. Gyde, (*Farmers' Almanack*, vol. 2, p. 19,) he found respectively 12.4, 10.5, and 8 per cent. only of fatty matters. The ashes or solid portions of three varieties of oil cake, however, examined by Mr. Fromberg, were found to contain per cent. of the earthy phosphates (*ibid.* vol. iii p. 31)—1, Gold of pleasure, 40.56; 2, English cake, 47.67; and 3, American cake, 38.28 (these ashes constituting of the first cake 6.89, of the second 7.25, and of the third 6.35 per cent. of the entire cake). In the case of guano, too, the same remark applies. We have already seen how its employment increases, according to Professor Johnston, the proportion of phosphate of lime in the turnip, and we may readily perceive from the results of the same excellent chemist's analysis of different varieties of guano, how very material a proportion of this manure is also composed of this salt. He found (*ibid.* p. 31) of the earthy phosphates—

In Peruvian guano from	16 to 23 per cent.
In Bolivian guano	25 to 29 „
In Saldanha Bay guano	43 to 56 „
In Algoa Bay guano	43 to 70 „

That the application of those manures, therefore, in which the phosphate of lime abounds generally increases both the fertility of

the soil and the *proportion* in which this salt exists, in the farmers' ordinary crops, we have no reason to doubt. It is ever present, too, in small proportions, in all cultivated soils, commonly in the largest proportions in those which are the most fertile. In 1000 parts of three varieties of soil examined by Mr. Gyde, (*Farm. Mag.* vol. 22, p. 414,) he detected in a soil fertile without manure 4½ parts phosphoric acid, and in a soil fertile with manure only 1½ parts, but in a naturally barren soil he could not detect any. An economical mode of dressing the land with this fertilizing salt has been recently adopted, with almost unvaried success, by mixing crushed bones with sulphuric acid (oil of vitriol); by this means the salt is converted into super-phosphate of lime (a salt very soluble in water, which the phosphate of lime can hardly be said to be), and the plan has the further advantage of very minutely dividing the particles of the bone, which in the ordinary way of application to the land is only a very gradual process. This fine state of division is so very desirable, that I have long been in the habit of following the plan almost universally adopted by the farmers of Lincolnshire and the north of England, viz., of preparing the crushed bones by previously causing a considerable degree of fermentation, and allowing them to thoroughly decompose by mixing them in the heap with a proportion of horse dung, and, in need, moderately moistening the mass with the drainage of the stable or farm-yard. In a short time, by persevering attention to these means, the bones are reduced to a fine powdery state, a much smaller proportion of which per acre we have seen very beneficially applied to exhausted land than is commonly employed. In the valuable paper of Mr. W. C. Spooner, of Southampton, (*Jour. R. A. S.*, vol. vii. p. 143,) an essay at once practical and scientific, the farmer will find many useful directions for mixing the sulphuric acid with the bones. He finds that the average weight of bone-dust as it comes from the mill is about 168 lbs. the sack of four bushels; that about one-third of this is composed of gelatine, cartilage, and fat; that these four bushels contain about 106 lbs. of phosphate of lime, which is composed of 59 lbs. of phosphoric acid and 47 lbs. of lime. From these data the farmer will be enabled to readily calculate the proportion of phosphate of lime of which his land is annually deprived, and the extent of the not very extensive necessary supply, where returned to it by the use of the ordinary modes. The chemistry of these dressings I have endeavoured to render simple, and thus I trust more generally understood. The effort has involved the necessity for some rather dry details, but these I well know, from long experience, will be readily forgiven for the sake of the cause by the intelligent and energetic farmers, for whom these researches were made, and for whom I hope long to have the honour of labouring.

SUPER-PHOSPHATE OF LIME.

The employment of super-phosphate of lime, now so extensive, can only be traced back to 1840. When Leibig published his "Organic Chemistry," he observed in that valuable work, p. 184, "To manure an acre of land with 40 lbs. of bone dust is sufficient to supply three crops of wheat, clover, potatoes, turnips, &c., with phosphates, but the *form* in which they are restored to a soil does not appear to be a matter of indifference. For the more finely the bones are reduced to powder, and the more intimately they are mixed with the soil, the more easily are they assimilated. The most easy and practical mode of effecting their division, is to pour over the bones, in the state of fine powder, half of

their weight of sulphuric acid, diluted with three or four pints of water. Experiments instituted on a soil formed from grauwacke, for the purpose of ascertaining the action of manure thus prepared, have distinctly shown, that neither corn, nor kitchen-garden plants, suffer injurious effects in consequence, but that, on the contrary, they thrive with much more vigour."

The first experiments with dissolved bones, according to Professor Johnston, (*Trans. High. Soc.* 1845, p. 92,) were made in 1841, by Mr. Fleming of Barrochan. "He dissolved his bones in muriatic acid, and applied them to moss oats." In his report, (*Johnston's Lec. on Agr. Chem. and Geology*, p. 28,) he says, "I examined the oats a few days before they were cut, and was much satisfied with their appearance; the straw appeared as stiff and thriving, and the ear was as well filled as if it had been grown upon stiff loam." In 1842 he made various other trials. From an application of the dissolved bones to turnips and potatoes, he obtained the following results, per imperial acre:—

	DRY BONE DUST.		BONES IN MURIATIC ACID.	
	16 Cwt.	18 Cwt.	4 Cwt.	10 Cwt.
	Tons. Cwt.	Tons. Cwt.	Tons. Cwt.	Tons. Cwt.
Swede Turnips . . .	14 17	— —	— —	18 11
Red Don Potatoes .	— —	9 15	12 15	— —

It might, indeed, have been reasonably anticipated that these valuable suggestions of Liebig, which I have already quoted, would hardly escape the attention of the farmers of this country. Various modes of preparing the super-phosphate of lime were suggested, and several manufactories immediately established. Of these, that of Mr. Edward Lawes must be regarded I believe as the earliest, and the most considerable. In 1842 a series of experiments were made by various members of the Morayshire Farmers' Club with this manure, the result of which led the Committee of that club to report, as the general result, their conviction that "a great discovery has certainly been made, which, if judiciously followed up, must tend to diminish very materially the heavy expense the farmer is now put to in raising a crop of turnips, from the very high price of bone manure." (*Jour. R. A. S.* vol. iv. p. 164.) They note that the turnips manured with the mixture of sulphuric acid and bones vegetated earlier, and with more rapidity; that turnips grown on soils manured with bones dissolved in sulphuric acid almost invariably ge[t] into their rough leaf more rapidly than when dressed with other manure appears to be well established. Mr. Spooner, of Southampton, in describing some comparative experiments (*Jour. R. A. S.* vol. vi. p. 73) remarks, "The *bones and acid* turnips were the first to appear above th[e] ground; the tops grew luxuriantly; the guano turnips, however, afte[r] some time rivalled them, and those manured with bones alone, thoug[h] lagging behind terribly at first, made amends towards the latter end o[f] autumn, and on weighing a few rods in the month of December scarcel[y] any difference could be discovered. To say the least, however," h[e] adds, "two bushels of bones, with the addition of the acid, successfull[y] rivalled eight times the quantity of bones;" and when Mr. R. W. Purcha[s] is recounting some very successful experiments with Swede turnips, h[e] reports, (*ibid.* p. 244,) "In every trial of acid and bones, the turnip[s] came into rough leaf a week before those planted the same day wit[h] other manures."

In the years 1843–4 a series of experiments were made. The results of some trials by the Duke of Richmond, at Gordon Castle, in Moray-shire, are thus stated by his Grace (*ibid.* vol. v. p. 443):—

"The soil is of a poor, light, sandy nature; the turnips, which were Dale's Hybrid, were sown in drills 27 inches apart, and one half drawn for cattle in the yards, the other half eaten on the ground with sheep. The land was afterwards sown down with Chevalier barley and grass seeds, without any manure. The lots consist of 1 imperial acre each. The tailings are not included in the underneath calculations:—

"Lot No. 1. Manured with 14 yards farm-yard dung, and 8 bushels of bone-dust.
2. " with 315 lbs. guano.
3. " with 16 bushels of bone-dust.
4. " with 2 bushels of bone-dust, dissolved in 83 lbs. of sulphuric acid, previously diluted with 12 gallons of water. This mixture was allowed to remain between two and three days in a tub, and then 388 gallons of water were added to it; the mixture was then applied to the drills in a liquid state, by means of a water-cart. "
5. " with 8 bushels of bone-dust, mixed with 83 lbs. of sulphuric acid, previously diluted with 12 gallons of water. This mixture, nearly in a dry state, was then sown with the hand along the drills.

Lots.	Cost of Manure.			Weight of Turnips.		Value of Turnips.			Produce of Barley.			Weight per Bushel.	Value of Barley.			Total Value of Produce.			Value after deducting cost of Manure.		
	£	s.	d.	Tons.	cwt.	£	s.	d.	Qrs.	B.	P.	lbs.	£	s.	d.	£	s.	d.	£	s.	d.
1	3	0	0	12	0	3	0	0	4	1	3	56	5	18	1½	8	18	1½	5	18	1½
2	1	17	4	11	4	2	16	0	3	5	1½	55	4	19	1½	7	15	1½	5	17	9½
3	1	16	0	11	0	2	15	0	3	7	1½	56	5	5	11	8	0	11	6	4	11
4	0	11	6	12	4	3	1	0	3	4	3	56	5	0	7½	8	1	7½	7	10	1½
5	1	5	0	11	0	2	15	0	3	6	2	56	5	6	9	8	1	9	6	16	9

In another series of trials with Dale's Hybrid Turnips on a light sandy loam, in 1845, (*ibid.* vol. vii. p. 297,) the following results per acre were obtained:—

	Weight of Bulb per Acre. Tons.	Cwt.
Land manured with 14 cubic yards of farm-yard manure, and 8 bushels of bones	12	18¾
14 yards of farm-yard manure, 1½ cwt. African guano . .	12	18¼
14 yards farm-yard manure, 2 bushels of bone dissolved in 50 lbs. of sulphuric acid, and mixed with 25 bushels of coal ashes	12	3
4 bushels of bones, 100 lbs. of sulphuric acid, 25 bushels of coal ashes	10	18¼
16 bushels of bones	8	11
3 cwt. of African guano	10	13¼

Of some experiments made in 1843, by Mr. R. W. Purchas, at St. Briavel's, in Gloucestershire, he gave the following report, (*Jour. R. A. S.* vol. v. p. 44) :—

" This trial was made upon a worn-out arable field of a sandy soil, sown the beginning of August, with improved stone-turnips in lots of a quarter of an acre. The ground was ridged up at 24 inches, the seed drilled on the ridge, and hoed out to 8 inches; the turnips were horse-hoed three times, and hand-hoed twice.

" The measure, weight, &c., are all calculated per imperial standard. One perch of each lot was pulled, topped, and weighed on the 8th of January, 1844.

No. of Lot.	Manure per Acre.	Expense per Acre. £	s.	d.	Produce per Acre. Tons.	cwt.	qrs.
1	15 yards fat pigs' dung, rotten	3	0	0	15	2	3
2	$3\frac{1}{2}$ bushels bone-dust, and 80 lbs. sulphuric acid (oil of vitriol)	1	0	6	13	1	1
3	40 bushels coal ashes, saturated with human urine in winter 1842–3	1	3	0	12	12	3
4	20 cubic yards road-scrapings, mixed with 280 gallons of human urine, and twice turned over in 1842	2	3	6	10	12	2
5	2 cwt. guano, mixed with 12 bushels pure charcoal-dust	2	1	0	10	5	3
6	7 cwt. urate	2	1	6	9	11	2
7	20 bushels bones (half dust)	2	14	0	9	1	0
8	6 bushels bone-dust, and 20 bushels charcoal-dust	1	13	0	8	17	0
9	4 bushels bone-dust, and 20 bushels charcoal-dust	1	14	0	8	17	0
10	16 bushels bones (half dust)	2	4	0	8	2	3
11	15 yards common straw dung (half rotten) .	1	10	0	6	13	1
12	No manure	...			1	10	2

In 1843 Mr. M'William, of Sherriffston, received the first premium of the Morayshire Farmers' Club, for his experiments with various manures. " They were conducted," remark the committee, (*Jour. R. A. S.* vol. v. p. 447,) " with the minutest care and attention, and would prove to agriculturists a most interesting study." " The whole field," observes Mr. M'William, " was half manured for wheat the previous year; Nos. 1, 2, and 3, got no manure for barley after the Swedes; No. 4 got no manure—in part Campbell's steep, in part clean water steep, and in part dry, quantities not yet tested—the rest of the field was equally manured (say half) all over for barley—no perceptible difference could be observed in the crop. The whole rather too heavy and lodged." The following is the result of his trials :—

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Number.		Rate per Imperial Acre. Loads of Dung, at 22d. per Load.	Bushels of Bones, at 2s. 4d. for Mixed, and 2s. 5d. for Dust.	Lbs. Sulphuric Acid, at 1¼d. per lb.	Guano, at 13s. per cwt.	Gypsum, at 4s. per cwt.	Sulphate of Ammonia, at 21s. per cwt.	Gallons of Water.	Dates of Sowing.	Expense per Imperial Acre.	Weight per Imperial Acre.
					Cwt. lbs.	Cwt. lbs.	Cwt. lbs.			£ s. d.	T. C. lbs.
	Swedish Turnips.										
1	Gibb's London Seed	27	1 3-5ths	46 2-5ths	...	...	...	397	May 31	2 18 2	17 15 86
2	Do. Do.	27	1 3-5ths	46 2-5ths	...	...	...	198½	June 2	2 18 2	18 12 16
3	Do. Do.	27	9 3-5ths	28	...	...	...	6	„ 3, 5	3 14 10	16 17 96
„	Laing's Swedes, raised at Sheriffston	27	9 3-5ths	28	...	...	...	6	„ 3, 5	3 14 10	18 15 0
	Common Turnips.										
4	Dale's Hybrid, raised at Sheriffston }	13½	1 3-5ths	46 2-5ths	...	...	...	397	„ 13	1 13 5 }	20 6 48
„	Gibb's Red-Top Yellow. }										13 13 64
5	Do. Do.	...	3 1-5th	92 4-5ths	...	...	...	794	„ 14	0 17 5	15 14 72
6	Gibb's Green-Top Yellow (Hybrid)...	...	3 1-5th	92 4-5ths	...	...	...	397	„ 15	0 17 5	15 17 56
7	Do. Do. 0. 2. 14 }	... }	5 1-9th	...	2 62	...	...	...	„ 15	2 5 1	16 11 88
8	Elgin Green-Top, Yellow, 0. 2. 13 }		5 1-9th	...	2 62	...	0 96	...	„ 17	3 3 1	15 14 72
9	Do. Do.	...	...	...	4 0	1 0	...	...	„ 17	2 16 0	15 15 0
10	Do. Do.	...	16	46	...	...	...	10	„ 19	2 2 1½	13 12 16
	Principally Green-Top White.										
11	Mixed Seed	...	3 1-5th	92 4-5ths	...	...	0 89¾	794	„ 20	1 14 3	17 9 72
12	Do. Do.	...	3 1-5th	92 4-5ths	...	...	...	397	„ 21	0 17 5	14 14 32
13	Do. Do.	...	3 1-5th	92 4-5ths	...	...	1 29½	397	...	2 3 10½	15 16 48
14	Do. Do.	...	16	46	...	...	...	10	„ 23	2 2 1½	14 0 0
	Short Drills—										
15	White Globe (Gibb's London) ...	...	...	...	2 15	...	...	...	„ 27	1 7 9	18 2 16
16	Dale's Hybrid (Sheriffston Seed)...	...	6½	...	0 62	...	...	...	„ 8, 10	1 2 4½	13 16 8
17	Do. Do. ...	...	...	...	1 86	...	...	...	„ 7	1 3 0	16 11 8
18	Do. Do. ...	...	16	46	...	...	...	10 }	„ 15, 17, 19, 20	} 2 2 1½	16 0 0
19	Green-Top White	...	3 1-5th	92 4-5ths	...	...	...	794	„ 28, 29	0 17 5	11 6 88

In some experiments of Mr. John Hannam, upon turnips, in 1843, (*ibid.*, p. 460,) the following results were obtained, on a very thin limestone soil, poor in condition:—

Date.	Manures and Quantity.	Application.	Produce per Acre. Tons. cwt. lbs.	Cost per Acre. £ s. d.
1843.	Bone-dust ... 16 bush.	Drilled with seed	15 3 4	1 13 0
	Bone-dust ... 8 bush. Sul. Acid ... 168 lbs. Water ... 604 lbs.	Diluted with water, equal to 50 times the weight of the acid, and applied in the furrow-ridge, ploughed up, and then seed drilled .	17 9 1	1 15 0
	Bone-dust ... 8 bush. Mur. Acid ... 168 lbs. Water ... 604 lbs.	Diluted and applied as above	17 7 1	1 19 6
	Bone-dust ... 8 bush. burnt to half original weight .... Sul. Acid ... 84 lbs. Water ... 252 lbs.	Diluted and applied as above	13 7 6	1 6 0
	No Manure	... ...	7 0 6	

In the same volume, p. 605, are given the results of several trials with various manures, carried on by the Right Honourable T. P. Leigh, at Kingsdown, in Kent. These experiments were "upon a clover-ley wheat crop, with farm-yard manure, ploughed in at the time of wheat sowing, about the 22nd November, 1843; and guano and other manures used as a top-dressing in the spring, on Tuesday, 19th March, 1844." The following results are per acre:—

	Cost. £ s. d.	Produce. Bush. Galls.	Pounds of Straw.	Weight per Bushel.	Increase. Bush. Galls.
Farm-yard Manure, 30 cart-loads	4 10 0	40 6	2,376	62¼	11 4
Peruvian Guano, 3 cwt. 2 qrs. 18 lbs., at 12*s.* per cwt.	2 4 0	40 6	2,196	62	11 4
Rape-dust, 5 cwt., at 6*s.* 6*d.* per cwt.	1 12 6	38 3	1,872	61	9 1
Urate, 6 cwt. 2 qrs., at 5*s.* per cwt.	1 12 6	38 5	2,028	60	9 3
Super-phosphate of Lime, 6 cwt. 1 qr. 4 lbs., at 7*s.* per cwt.	2 4 9	53 5	2,940	61	24 3
Soil Sample	0 0 0	29 2	1,472	61	0 0

Some valuable experiments by Mr. R. D. Drewett, of Peppering, near Arundel, with Swedish turnips, (*Jour. R. A. S.* vol. vi. p. 581,) are remarkable, as well supporting the opinion to which I have already referred, that it is to the saline portion of the bones that their chief fertilizing powers are due:—

Description of Manure, per Acre.	Produce per Acre. Tons. cwt. lbs.	Tons. cwt. lbs.
3½ cwt. African guano . . . 5 bushels turf ashes . . . . 200 bushels superior dung . .	9 12 24	0 16 48
3½ cwt. African guano . . . 25 bushels turf ashes . . . . 200 bushels of dung	13 1 0	0 17 9
3¼ cwt. of Peruvian guano . . 25 bushels of turf ashes . . . 200 bushels of dung	9 2 16	0 14 68

times; and in the course of seven or eight weeks the compost becomes dry, and breaks down with a shovel in a state fit for spreading with the hand in the drill."

And lastly, as to the preparation of the manure by the farmer, Mr. Spooner has given, in his Prize Essay, some valuable directions. (*Jour. R. A. S.* vol. vii. p. 147.) He observes:—

"Sulphuric acid, or oil of vitriol, as it is more frequently termed, consists of the union of two parts by weight of sulphur with three of oxygen gas, and its strength depends on its purity and freedom from water, for which it has a remarkable affinity; so much so, that if exposed to the air it will quickly absorb water from the atmosphere. Its relative weakness, therefore, is owing to the quantity of water mixed with it. In speaking of sulphuric acid, I must be understood to mean in its concentrated state, possessing a specific gravity of from 18.45 to 18.50. And it should be borne in mind, in purchasing the acid, that 50 lbs. of the above is at least equal to 67 lbs. of the specific gravity of 1.714, and therefore, if the weaker acid is used, its quantity must be increased in proportion to the diminution of its strength.

"On applying the vitriolized bone to the tongue, we find that it tastes both sour and sweet. The sourness arises probably from the phosphoric acid, and the sweetness from the gelatine sugar, which is formed by the action of the acid on the gelatine, converting a substance very difficult of decomposition into one readily soluble, and which can be easily absorbed by plants. When concentrated acid is mixed with a quarter of its weight of water, the temperature of the mixture is raised to 300°, and boils away at a great rate. The action of this heat on the animal part of the bones renders it of a dark colour; but, if a small quantity of acid only be employed, the mixture is white, from the carbonate of lime which then predominates. From an average taken from several analyses of bones of man and various animals, the following appears to be tolerably near the mean:—

Organic matter, consisting of gelatine, cartilage, and fat .	34
Phosphate of lime and magnesia	59
Carbonate of lime	7

Or, in rough numbers, the organic matter may be regarded as forming one-third, and the earthy portions two-thirds. Of course, if the bones are very fresh, the former will be in larger proportion than one-third; thus, Mr. Hannam gives it as 45 per cent. The above, however, may be considered as a fair average in the state usually employed by farmers.

"Four bushels of bones, which may be considered to be a fair allowance for an acre, will weigh, in a fine state of bone-dust, about 180 lbs.* This quantity contains 12½ lbs. of carbonate of lime, consisting of carbonic acid 5½ parts, and lime 7 parts, which will require 10 lbs. of sulphuric acid to convert it into sulphate of lime, or gypsum. This is the first result of the mixture, and is the cause of the very unpleasant fumes which are given off, and which consist in fact principally of carbonic acid disengaged from the carbonate of lime in consequence of the superior affinity which lime has for sulphuric acid. This result takes place before the acid acts on the phosphates of the bones, and thus it is that, when a small quantity of acid has been sprinkled over bone-dust, the good effect has been but moderate, the carbonate of lime

* I find that the *average* weight of bone-dust, as it comes from the mill, is 168 lbs. per 4 bushels, although I *have* found it reach the weight stated in the text.—AUT.

alone has been acted on, and the phosphate of lime has remained undecomposed.

"The quantity of phosphate of lime existing in the four bushels of bones is about 106 lbs., containing 47 lbs. of lime and 59 lbs. of phosphoric acid. If we consider super-phosphate of lime to contain a double portion of acid—a fact, however, not quite decided—then, 33 lbs. of sulphuric acid will be required, which, by uniting with half the lime, or 23½ lbs., forms gypsum, and leaves the other moiety of lime united with a double portion of phosphoric acid in the state of a super-phosphate. Thus, 45 lbs. of acid will be required to effect these changes, leaving any additional quantity for other purposes."*

Such are the modes of preparing the home-made super-phosphate of lime. As met with in commerce, it ought to contain when genuine, in 100 parts, according to Mr. Pusey, (*Farmer's Mag.*, vol. xxvi. p. 307,)—

Phosphate and biphosphate of lime	35 to 40
Sulphate of lime	20 25
Animal	20
Water	20

But it is often mixed with other substances, which naturally reduce its value; a specimen examined by Mr. Lawes (*ibid.*) contained—

Super-phosphate of lime	14
Sulphate of lime (*gypsum*)	64
Water	20
Residue	2

GUANO.

The historian of agriculture, in tracing its progress during the last few years, will hardly fail to notice, as perhaps the most remarkable of its many improvements, the rapid and successful introduction of those manures, such as super-phosphate of lime and guano, whose chief fertilizing ingredient is the phosphate of lime. Of these, guano must be regarded as the most extensively employed of the class. Long employed by the cultivators of Peru to manure their irrigated lands, its value was first alluded to as likely to be serviceable to the English farmer about the year 1810, by the late Sir Humphrey Davy, (*Agricultural Chem.* p. 296,) and in that year a series of trials with guano as a manure for potatoes and mangold wurtzel were made at St. Helena, by General Beatson. (*Com. Board of Agri.* vol. vii. pp. 225-240.) More than a quarter of a century elapsed, however, before any attempts were made to import it into this country; for it was not until the year 1840 that about twenty casks of guano were imported by Mr. Myers of Liverpool. Its powers, however, being once practically ascertained, cargoes of guano began in 1841 to arrive from the Pacific, and the rapidity with which the demand arose for it, and its extent, may be seen from the following table of imports, (*Parl. Paper*, 1846; *Farmer's Almanack*, vol. iii. p. 9:)—

Vessels entered inwards.	British Vessels.		Foreign Vessels.	
	Ships.	Tons.	Ships.	Tons.
In the year 1841	7	1,733	...	...
„ 1842	41	12,003	3	1,091
„ 1843	13	4,056	...	...
„ 1844	286	81,902	1	207
„ 1845	679	219,764	4	1,170

* I do not mean to say that these are the precise changes which take place, but only an approximation to them. Probably some portion of phosphoric acid may be left in a free state in the prepared mixture.

The great demand for the Peruvian guano immediately set to work the enterprising merchants of England in search of other districts in which guano might be procured. Deposits of it were speedily discovered in Patagonia, and on the coast of Africa. Large quantities of these varieties were imported, but their quality was found to be generally inferior to the guano of Peru. Most of those of commerce have been analyzed by Professor J. F. Johnston. (*Ag. Gaz.* vol. iii. p. 244.) He found in these, per cent., (*Farmer's Almanack*, vol. iii. p. 31,)—

Kinds.	Water.	Ammoniacal matter.	Earthy phosphates.
Peruvian . . .	7 to 9	56 to 66	16 to 23
Chilian . . .	10 13	50 56	22 30
Bolivian . . .	6	65 64	25 29
Ichaboe . . .	18 26	36 44	21 29
Saldanha, light .	17 27	14 22	43 56
„ dark .	33 44		
Algoa Bay . .	2.26	22.37	70.20
	23.93	23.16	43.15
Halifax . . .	24.47	20.61	22.67
Bird's Island .	25.49	19 to 21	22.43
„ „ .	14.18		5.37
Patagonian, light	40.99	20 25	24 to 32
„ „ dark	20.55		

Guano is, as I have elsewhere remarked, (*Fertilizers*, 481,) the European mode of pronouncing the Peruvian word "huhanu" or "huano," or manure. This substance exists in large quantities in some of the rocky islands off the coast of Peru, where, in the course of ages, it has been formed by the deposit of the excrements of innumerable multitudes of sea-fowl, who haunt these localities, especially during the breeding season*. It exists, according to M. Humboldt, (*Davy's Elem. Ag. Chem.* 296,) in the greatest abundance in some of the small rocky islands of the Pacific Ocean, as at Chinche, Ilo, Iza, and Arica. Even when Humboldt wrote, some twenty years since, fifty vessels were annually loaded with the guano at Chinche alone, each trader carrying from 1500 to 2000 cubic feet. The guano is found, according to Liebig, (*Organic Chem.* 81,) on the surface of these islands, in strata of several feet in thickness, and is, in fact, the slowly putrefying excrements of innumerable sea-fowl that remain on them during the breeding season. It is used by the farmers of Peru chiefly as a manure for the maize or Indian corn, and it is said sometimes in the small proportion of about one cwt. per acre. "The date of the discovery of the guano and of its introduction as a manure," says Mr. Winderfeldt, (*Brit. Farm. Mag.* vol. vi. p. 411,) "is unknown, although no doubt exists of its great antiquity. In many parts of America, where the soil is volcanic or sandy, no produce would be obtained without the guano. 'It has been calculated that from 12,000 to 14,000 cwts. are annually sold in the port of Mollendo for the use of the country round the city of Arequipa. In the province of Taracapa and in the valleys of Tambo and Victor the consumption should be something more, as wheat, all kinds of fruit, trees, and plants, with the single exception of the sugar-cane,

* "It forms irregular and limited deposits, which at times attain a depth of 50 or 60 feet, and are excavated like mines of red ochre. Its real origin was well known to the Government of the Incas, and its national importance fully understood. It was made a capital offence to kill the young birds on the Guano Islands."—(*Professor Johnston, Jour. R. A. S.* vol. ii. p. 301.)

are manured with the guano; which is not the case with the district of Arequipa, where maize and the potato alone require it. In the district of Arequipa 3 cwts. of guano are spread over an extent of 5000 square yards, (about an English acre;) but in Taracapa and the valleys of Tambo and Victor, 5 cwts. are required. The land thus manured in Arequipa produces 45 for 1 of potatoes, and 35 for 1 of maize, where wheat manured with horse-dung produces only 18." There are, it appears, three varieties of guano, which bear on the coast of Peru different prices. "The white guano is considered the most valuable, as being fresher and purer. It is found on nearly all the islands along the coast. The red and dark grey are worth 2*s*. 3*d*. the cwt.; a higher price is given for the white on account of its greater scarcity; it is sold at the port of Mollendo at 3*s*. 6*d*. per cwt., and at times, as during the war, it has obtained as high a price as 12*s*."

From the analysis of different varieties of guano by Professor Johnston, which I have already given, (*ante*, p. 134,) the farmer will notice that its value increases with the proportion of the salts of ammonia which it contains, and this proportion is naturally the largest in specimens obtained from the islands of the Pacific, situated in a region of perpetual dryness, where the guano deposits remain for ages unwashed by a single shower. It is probable, however, that the excrements of the birds of which it is composed undergo a gradual decomposition, "since," as Professor Johnston observes, (*Jour. R. A. S.* vol. ii. p. 311,) "the fresh guano is more valuable, because it contains more of the uric acid." We have no analysis of the recent droppings of any of the birds which frequent the shores of Peru; they would probably be found to differ in some degree, not only with the species of bird, but also with the kind of fishes on which at different seasons of the year they were found to prey. We possess analyses, however, of the excretions of other birds which live chiefly upon fish, from which we are enabled to form an opinion as to what the recent guano is likely to be. Thus Dr. Wollaston found those of the gannet, (*Pelicanus bassanus*,) when dry, to contain little else but uric acid, while in those of the sea eagle Coindet found—

SOLID EXCRETIONS.	Per cent.	LIQUID EXCRETIONS, DRIED.	Per cent.
Ammonia	9.2	Earthy and alkaline phosphate, sulphates, and chlorides	41
Uric acid	84.65		
Phosphate of lime	6.15		
Uric acid	.59		

In 1841, guano was tried by various cultivators with very general success; by Mr. Pusey, at the rate of 3 cwts. per acre on Swedes, the manure being drilled under the seed. This, however, was found to be an erroneous plan; the guano being placed too closely in contact with the roots of the young turnips produced an injurious effect. (*Jour. R. A. S.* vol. ii. p. 303.) Mr. Love, of Castle Farm, who used it for the same crop, adopted the precaution of previously mixing the guano with about six times its weight of ashes, such as are obtained by burning the earth gathered round the borders of fields and hedgerows. (*Ibid.* p. 304.) Professor Johnston has added the results of other trials made in the same year, which are interesting as showing the earliest efforts which were made in this country to test the value of this now extensively employed fertilizer.

Mr. Westcar, of Burnwood, Surrey, tried 7½ lbs. upon 5 rods of land, drilled in with barley and clover. Upon other 5 rods he applied the best farm-yard manure, at the rate of 18 loads to the acre, and sowed on these an equal quantity of the same seeds. The result was—

From dung, 18 loads to the acre . .	1 bushel	3 quarts.	
From guano, 2 cwt. to the acre . .	1 „	7 „	

Mr. Smith, of Gunton Park, applied 4 bushels, about 200 lbs., of guano to a statute acre; and on another equal portion of land on the same field, applied 15 bushels (6 cwt.) of bone-dust. Both were drilled into the ground with the seed-wheat. The guano gave 6 qrs. 2 bushels 1½ peck; the bone-dust only 4½ qrs. of wheat.

In an experiment of Mr. Skirving, at the Walton Nurseries, near Liverpool, three plots of ground were manured respectively with guano, nitrate of soda, and farm-yard manure; and to a fourth portion nothing was applied. All the four were sown with Italian rye-grass, on the 19th of May; and all were cut on the 2nd of August last. The results were as follows:—

	tons.	cwt.	lbs.
Guano, 3 cwt. per acre	14	15	26
Nitrate of soda, 3 cwt. per acre . .	14	13	37
Farm-yard manure, 20 tons per acre .	13	2	96
Without manure	7	0	108

Mr. Skirving adds, " that the experiment was made on poor light black soil, inclining to peat. The land was first dug over, and then the manures spread on it and lightly dug in. On account of the very dry weather at the time of sowing, the seed did not come up very soon on any of the plots, but when the rain came the crop appeared; and on the nitrate of soda and guano made more rapid progress, by a great deal, than on the farm-yard manure, and continued to do so until I was obliged to cut the crop, its luxuriance being such, both on the guano and soda, that it was all down and lodged, and injured the roots."

It hardly becomes necessary to follow these successful trials much further, they now began to multiply in all directions, and in selecting another reported experiment upon turnips, made in the following year, I do so because of these being carried on in conjunction with other manures, of which the phosphate of lime was also a very chief fertilizing constituent. In these, which were made by Mr. Thomas Stiles of Spalding. (*Farmer's Mag.* vol. viii. p. 283.)

Dales' hybrid turnips, sown on the 27th June, 1842, on ridges 27 inches apart. The soil a rich loam with a sandy subsoil.

		Expense per acre.	Produce. Tons.	Cwt.
[illegible] farm-yard manure.	No. 1.—6 cwt. of urate mixed with ashes .	36*s*.	15	10
	No. 2.—6 cwt. of urate, 6 bushels of bones and ashes	54*s*.	17	10
	No. 3.—1½ cwt. of guano, 4 bushels of bones and ashes	42*s*.	21	4
	No. 4.—12 2-horse cart-loads of rich farm-yard manure	36*s*.	19	8

Ten loads of rich farm-yard manure, ploughed into the ridges, at 8s. per load.

	Expense per acre.	Produce. Tons.	Cwt.
No. 5.—6 cwt. of urate, with ashes, 10 loads of well-made farm-yard manure	66*s*.	20	0
No. 6.—6 cwt. of urate, 6 bushels of bones and ashes, 10 loads of the same manure .	84*s*.	21	2
No. 7.—12 bushels of bones, 3 cwt. of urate, ashes, 10 loads of manure	84*s*.	20	15
No. 8.—1½ cwt. of guano, 4 bushels of bones, ashes, 10 loads of manure	72*s*.	22	0
No. 9.—12 bushels of bones, ashes, and 10 loads of manure	66*s*.	20	0
No. 10.—2 cwt. of guano and ashes, 10 loads of manure	70*s*.	20	0

In that and the succeeding year so many and such successful experiments were made, as fully to justify the conclusion described by Mr. Dudgeon of Spylaw, (*Trans. High. Soc.* vol. ix. p. 67,) when speaking in 1843 of the progress of the introduction of concentrated manures, "The first advance to this desired end—and it was a most important and rapid one—was the application of ground bones to the soil, by which, besides the saving in the cost of the material compared with other manures, an immense advantage was obtained in the facility, and, above all, economy in carriage and distribution. A further movement has now, it would appear, been effected in this direction to a still greater extent by the use of guano, which, in the amount of weight required, it may be safely said as to bones, is as one to four; and thus has been nearly restored something equivalent to that boast of science which has been often quoted by practical men, only to be spurned, that the day would come when a person should carry in his pocket manure sufficient for an acre of land; for certainly there is a near approach to a fulfilment of this predicted achievement, when we find an ordinary cart-load of manure is sufficient for a field of ten acres.

In Mr. Dudgeon's experiments (*ibid.* p. 70) with Dale's hybrid turnips, he tried the guano in drills, with farm-yard dung on those adjoining. The rates of the manure applied, as given in the following statement, are per acre. The produce is that of the drill's breadth.

		Weight of bulbs produced. Cwt.	Sts.
Two drills with guano	5 cwt.	25	5
Two „ „ dung	18 yards	18	7
Two „ „ guano	4 cwt.	22	6
Two „ „ dung	18 yards	19	7
Two „ „ guano	3 cwt.	20	6
Two „ „ dung	18 yards	19	2

Like many organic manures, guano must not be expected to produce very satisfactory results in dry seasons. Its failure in 1845 was general. In 1844, Mr. David Barclay made some trials with this and several other manures, which afforded an instance of the truth of this fact. (*Jour. R. A. S.* vol. vi. p. 176.) These were made at Eastwick Farm, in Surrey:—

Description of Manure.	Quantity used per Imperial Acre.	Cost of Manure, Carriage, and Application.	Produce of trimmed Swedes per Acre.	Value of Produce at 15s. per Ton.	Cost of Manure and Application per Ton of Swedes.
			T. cwt. qr. lb.	£ s. d.	s. d.
Farm-yard	12 tons	At 5s. . £3 0 0 Carriage 1 4 0 Spreading 0 4 0 4 8 0	9 7 3 20	7 1 0	9 4
African guano	3 cwt.	At 6l. 10s. per ton. 0 19 6 Sowing 0 2 0 1 1 6	8 2 0 0	6 1 6	2 8½
Peruvian guano	3 cwt.	At 10l. 10s. 1 11 6 Sowing 0 2 0 1 13 6	8 0 0 0	6 0 0	4 2½
Potter's guano	4 cwt.	At 12l. 2 8 0 Sowing 0 2 0 2 10 0	8 17 2 8	6 13 2	5 7½
Humphrey's farmer's compound	3 cwt.	At 12l. 1 16 0 Sowing 0 2 0 1 18 0	5 17 3 0	4 8 3¾	6 6

Some experiments of Lord Blantyre are interesting, as they tend to elucidate the question, often mooted amongst farmers, to what extent guano may be beneficially applied—trials, which may be usefully studied in conjunction with the subsequent investigations of Mr. Pusey. (*Quar. Jour. Ag.* 1846, p. 199; *Farmer's Almanack*, vol. iii. p. 97.) The soil employed in these experiments was poor and light. The manure used, and the produce of yellow turnips per acre, were—

	Tons.	Cwt.		Tons.	Cwt.
Dung, 5 tons; bones, 30 bushels . .	23	17	Guano, 9 cwt. . .	28	16
Guano, 3 cwt. . .	26	2	„ 10 „ . .	31	0
„ 4 „ . .	27	6	Calcined bones, 30 bushels . . .	25	8
„ 5 „ . .	28	16	Do. 45 bushels . .	24	12
„ 6 „ . .	29	8	Animal charcoal, 30 bushels . . .	25	0
„ 7 „ . .	31	9	Do. 45 bushels . .	25	8
„ 8 „ . .	27	6			

With potatoes on a similar soil the results were per acre—

	Bolls.	Pecks.		Bolls.	Pecks.
Soil simple	10	2	Guano, 4 cwt. . .	25	12
Dung, 30 tons . .	47	10	„ 6½ „ . .	34	6
„ 30 „ . .	43	12	„ 7½ „ . .	31	4
Guano, 3 cwt. . .	21	1	„ 8 „ . .	34	6

In 1845, Mr. Pusey made some very valuable trials with guano, farm-yard, and other manures, to elucidate one or two most important questions in the application of manures, which were to find, to use his own words, (*Jour. R. A. S.* vol. vi. p. 529,) " to what degree, for instance,

one may increase the dressing of dung, with corresponding benefit to the crop, and what is the limit beyond which an increased quantity of dung ceases to act; or, again, whether it be better to dress with dung only, or with a combination of dung and of artificial manure." In order to investigate these, and other points, I applied to five acres of yellow globe beet, in the first week of April, different dressings per acre of various manures.

At the end of October the roots were taken up, and the produce ascertained by weighing the yield of half an acre, measured across the six sets of rows at one end. The yield was as follows:—

	Dung.	Artificial Manure.	Tons of cleaned Roots per Acre.
No. 1.	26 loads	. . . .	28½
2.	13 loads	. . . .	27½
3.	13 loads	7 cwt. rape-dust . . .	27
4.	13 loads	14 bushels bone-dust . .	26
5.	13 loads	7 cwt. rags	36
6.	13 loads	3 cwt. guano	36
7.	. .	7 cwt. rape	20½
8.	. .	14 bushels bones . . .	20
9.	. .	3 cwt. guano	20½
10.	. .	. . . .	15½

By comparing the two first lots, it appears that in doubling the dose of dung we had gained only 1 ton per acre, which is in fact gaining nothing. It is proved, therefore, that on some land, though poor, if in high condition, there is a point beyond which even a large increase of mere dung ceases to act. But the clearest mode of examining the result of the trial will be to divide the lots into classes, according to the amount of produce, and it will be found that they fall easily into classes, —an agreement which can hardly be accidental, and leads to the belief that some uniform causes have been at work.

First we must of course take the soil in its actual state—not its natural state, for it is naturally poor—but in its then state of productiveness as it stood without further assistance.

Soil unmanured. 15½ tons of field-beet.

This will of course form the standard by which to judge the effect of the other manures. The artificial manures evidently follow next, their produce running very even. Rags used singly were accidentally omitted from the trial; but having used them in the same field and seen their yield, I should put them at the some amount with the rest.

The second class then will stand thus:—

Artificial Manures alone.	Tons.
7 cwt. rape	20½
14 bushels bones	20
3 cwt. guano	20½
7 cwt. rags, (*estimated,*) about	20

The agreement, by actual weighing, between the three first artificial manures is very close. The effect of all is but weak, and the increase of crop would barely pay for their use, being only 5 tons, worth about 50*s*. to consume on the land.

The third class evidently marks itself out as follows:—

	Artificial Manure.	Tons.
13 loads dung		27½
13 loads dung .	7 cwt. rape-dust	27

	Artificial Manure.	Tons.
13 loads dung	14 bushels bones	26
26 loads dung		28½

These amounts again may be taken as practically the same. No adva tage is gained by exceeding the single dressing of dung. It seems confirmation of the inference, that there is a limit to the profitable use dung, to find that bones and rape-dust, each efficient when used alor fail equally with the additional dose of dung in raising the produ above the standard amount, in which there certainly is a striking agre ment between the four lots. In the second class, then, the artifici manures gave each about 5 tons additional produce per acre. In tl third class, the single dressing of dung gives about 12 tons, which is n increased by the further use of bones, rape, or sensibly even by doublir the dung.

The remaining class shows a different result:—

13 loads of dung	7 cwt. rags	36 tons.
13 loads of dung	3 cwt. guano	36 tons.

Here we obtain a very large increase by adding two different artifici manures separately to the full dose of dung. The question arises, wh these two manures should act so much better?—a question I am unabl to answer. But in the interesting work on "Rural Economy," whic Boussingault has lately published, and Mr. Law has translated, there i a very copious table in which the value of manures is stated accordin to the quantity of azote which they contain. In that table the manure we are now dealing with stand thus:—

	Azote.
Rape-dust	5½
Bones	6¼
Best guano	15¾
Woollen rags	20¼

BRITISH GUANO.

The use of the excrements of the wild fowl of our coasts was first suggested in 1843 by Sir H. Davy. (*Agr. Chem.* p. 297.) He observed, "It is probable that even the sort of the small islands on our coast much frequented by them would fertilize. Some dung of sea-birds, brought from a rock on the coast of Merionethshire, produced a powerful but transient effect on grass. It was tried, at my request, by Sir Robert Vaughan, at Nannau." The difference in the composition of British guano (an analysis of which I shall subjoin) and that from South America is explained, not only by Davy, but by Professor J. F. Johnston, when he remarks, (*Jour. R. A. S.* vol. ii. p. 314,) "Nearly the whole of the land along this coast, between the Cordilleras and the sea, is one continued desert. 'I have always,' said Mr. Darwin, (*Researches*, p. 428,) 'applied the terms barren and sterile to the plains of Patagonia, yet the vegetation there can boast of spiny bushes and some tufts of grass, which is absolute fertility to any thing that can be seen here' (the neighbourhood of Copiapó). 'In Peru real deserts occur over wide tracts of country.' 'It has almost become a proverb that rain never falls in the lower parts of Peru.' 'That much rain does not fall is very certain, for the houses are covered only with flat roofs made of hardened mud; and on the mole (at Callao) ship-loads of wheat were piled up, and are thus left for weeks without any shelter.' (*Ibid.* p. 446.) 'The town of Iquique contains about 1000 inhabitants, and stands on a little plain of sand at the foot of a great wall of rock 2000 feet in height,

which here forms the coast: the whole is utterly desert. A light shower of rain falls only once in very many years; and hence the ravines are filled with detritus, and the mountain-sides covered by piles of fine white sand, even a thousand feet high.'

"It is the dryness of the climate then which has permitted the guano to accumulate on these coasts. When we reach a region in which from local causes the dews are heavier and the rains more frequent, the accumulation ceases. Cold water, we have seen, dissolves at least three-fifths of the guano in the state in which it reaches us. A single day of English rain would dissolve out and carry into the sea a considerable portion of one of the largest accumulations; a single year of English weather would cause many of them entirely to disappear."

Some guano, collected from Ailsa Craig by Dr. Balfour, and a specimen from the coast of Ireland, was found to contain (*Quar. Jour. Agri.*, 1845. p. 59):—

	FROM AILSA CRAIG.	FROM IRELAND.
Water	50.30	50.20 (Water and organic matter together)
Organic matter and ammoniacal salts, containing 3.47 per cent. of ammonia.	12.50	
Phosphate of lime Phosphate of magnesia	12.10	21.15
Oxalate of lime	1.50	3.80
Sulphate of potash Phosphate of potash Chloride of potassium	1.0	1.0
Earth matter and sand	15.0	28.85

GYPSUM *.

We have already seen how very extensively two of the salts of lime, the carbonate of lime, (*chalk*,) and the phosphate of lime, (*bones, &c.*,) are now employed as manures. There is a third, the sulphate of lime, (*gypsum*,) whose use has, within the last few years, very materially increased. The most successful use of this salt is for clover, lucern, and sainfoin. Turnips, also, have been on some soils successfully dressed with it. In the United States it is employed for every kind of crop. Professor Johnston (*Elem. Chem. and Geo.* p. 183,) deems it especially adapted, besides clover, to the pea and the bean crop. "It supplies to the soil," he says, "the lime and sulphuric acid which are annually removed by the crop." Davy arrived at a similar conclusion in explaining the use of gypsum as a manure. "It has," he remarked, when speaking of the operation of gypsum and the alkalies, "been generally supposed that these materials act in the vegetable economy in the same manner as condiments or stimulants in the animal economy, and that they render the common food more nutritive. It seems, however, a much more probable idea that they are actually a part of the true food of plants, and that they supply that kind of matter to the vegetable fibre, which is analogous to the bony matter in animal structures: thus, those plants which are most benefited by the application of gypsum, are plants which always afford it on analysis. Clover, and most of the artificial grasses, contain it, but it exists in very minute quantity only in barley, wheat and turnips." This opinion of Sir Humphry Davy was not a hastily adopted conclu-

* *See "British Husbandry," vol. i. p. 323.*

sion; for he says in another place, "In examining the ashes of sainfoin, clover, and rye-grass, I found that they afforded considerable quantities of gypsum; and this substance, probably, is intimately continued as a necessary part of their woody fibre. If this be allowed, it is easy to explain the reason why it operates in such small quantities; for the whole of a clover crop or sainfoin crop on an acre, according to my estimation, would afford by incineration only three or four bushels of gypsum." (*Agri. Chem.* 332.)

There is, indeed, as I have elsewhere remarked, (*Farmer's Encyclo.*,) no reason to believe but that the proportion of sulphate of lime found in certain plants is as essential to their growth as the presence of the other earthy salts and pure earths. Thus, those plants which yield this salt never grow well on lands which do not contain it; those in which carbonate of lime is found never flourish in soils from which this salt is absent. Plants which abound with nitrate of potash, (saltpetre,) such as the sun-flower and the nettle, always languish in soils free from that salt: but, when watered with a weak solution of it, their growth is very materially promoted; and the saltpetre is then found, as shown upon analysis, in very sensible proportions. The same remarks apply to the growth of those plants which contain common salt, or phosphate of lime: the effect is the same, the result invariable.

Liebig, however, explains the operation of gypsum in another way. He contends that the nature of gypsum consists in its giving a fixed constitution to the nitrogen or ammonia, which is brought into the soil, and is indispensable for the nutrition of plants. He says that 100 lbs. of gypsum fixes as much ammonia as 6250 lbs. of horses' urine would yield to it. 4 lbs. of gypsum, he affirms, increase the produce of the meadow 100 lbs. The decomposition of gypsum is slow, which, he says, explains the reason why the action of gypsum lasts for several years. (*Organic Chemistry*, p. 87.)

But this appears to me to be a very unsatisfactory explanation of the phenomena; for sulphate of ammonia, which M. Liebig supposes to be thus formed by the union of the ammonia with the sulphuric acid of the gypsum, is a manure to several other crops besides the grasses, crops to which the application of gypsum is, as every farmer well knows, utterly useless. It is not, therefore, only by the formation of sulphate of ammonia, I think, that gypsum operates as a fertilizer.

And again, if this was the true explanation, we might surely expect that the application of this salt would be more *generally* useful, and that its benefit would not be confined to those cases in which sulphate of lime is naturally absent from the soil. Many cultivated soils, however, contain it in sufficient quantities for the service of the plant, and hence the reason why gypsum so often fails to produce benefit. The chief active constituent of peat ashes is the sulphate of lime; on those soils, therefore, where peat ashes are found advantageous, the use of gypsum will pretty certainly be found still more beneficial. "In examining," remarked Sir H. Davy, "the soil in a field near Newbury, which was taken from a footpath near the gate, where gypsum could not have been artificially furnished, I could not detect any of this substance in it; and at the very time I collected the soil the peat ashes were applied to the clover in the field." The reason why gypsums are not generally efficacious is probably because most cultivated soils contain gypsum in sufficient quantities for the surface of the grasses. "I have examined," continues Davy, "four different soils for gypsum; a light sand from Norfolk; a clay from Middlesex; a sand from Sussex; and a clay from

Essex; I found gypsum in all of them; and in the Middlesex soil it amounted to nearly 1 per cent."

It has been found that, in applying gypsum to the grasses as a top-dressing, no other mode is so advantageous as to spread it, early in the spring, in the state of fine powder, on a wet morning, when the leaves of the plants are so damp that the flour of the gypsum adheres to them. These points are alluded to by Mr. James Barnard, an extensive and excellent farmer of Little Bordean, in Hampshire, who thus described to me the results of his trials with gypsum (*Jour. R. A. S.* vol. ii. p. 110):—

"The soil of my farm is of a clayey nature, and would be very stiff but for the number of stones there are in it. I have sown gypsum six or seven years, and never on clover or sainfoin without satisfactory proof of its efficacy, having usually grown half a ton more of hay per acre by its use. But the effect in 1838 was wonderful. I put on a bag (2¼ cwt.) per acre, on a two-year old piece of sainfoin, on the 1st of May, with the plants very forward, just leaving the ground and coming to stalk: the gypsum had so increased the growth of the grass by the 9th of the same month, that, when crossing the land with a friend, we observed the difference from one of the fields to the other; and at harvest time the extra produce of hay was quite one ton per acre. I then laid the field up, and cut it again in October; when the effect of the gypsum was still more apparent, there being 1¼ ton of hay per acre from the so dressed portion of the field, and scarcely any on the remainder of the land. Cutting the sainfoin twice in one year, and the enormous difference in the produce, brought a great many persons to look at the field, who all declared they had never seen the like before. On the same piece, this year (1839), I did not use gypsum, thinking it would be good enough without, and the difference was quite as great. I mowed twice the gypsumed portion, but there was nothing to cut on that which had not the gypsum. I can even see the effect where, three years ago, the gypsum was spread. I always leave a strip or two in every field to prove the effect. There is one thing more I wish to observe, that I never put on gypsum before the last week in April, or the first in May; and choose, if possible, a moist morning. I have not found much good effect from its application on either chalk or cold clay soils."

There is, in fact, no doubt of the great advantage of sowing the gypsum in wet weather. Arthur Young tried it unsuccessfully on clover, in 1790; but when he repeated his experiments in 1791 he tells us that "fine rains fell soon after, which washed the gypsum in;" and he was entirely satisfied with the result. "The clover thus manured was not only considerably higher, but thicker, of a far deeper and more luxuriant colour, and of a broader leaf." It did no good, he found, to his wheat: he employed it at the rate of five bushels per acre. "I am quite confident," he adds, "that neither such a quantity of night soil, pigeon's dung, peat ashes, nor any other manure with which I am acquainted, would have had an equal effect." (*Annals of Agri.* vol. xvi. p. 185.) And the observations of Parkinson are to the same effect:—"There ought," he observes, "to be great attention paid to sowing the plaster, after a shower of rain; in America, they are very particular in this respect. I know this makes a wonderful difference; as I tried, in a small degree, by laying some on turnips when dry and when wet; but the last proved by far the best. The second of these applications was made just after a remarkably heavy shower, and I observed this plaster to be

quicker in bringing the plants forward than I had ever known before, although I always endeavoured to put it on when the land was as wet as I could find it." (*Prac. Observations*, p. 98.)

There can be no doubt, notwithstanding the thus explained apparently contradictory results of the trials with gypsum as a manure, that it is a most useful agent in the hands of the farmer: as a sprinkling for the floors of stables, sheep-sheds, and other buildings where animals are confined, to prevent the escape of ammonia; and for the same purpose, to mix with or cover compost herbs, the value of gypsum is material; and its use is yearly becoming more extensive. I will here add the results of a few of the modern experiments on this salt, and I will, in doing so, select also some of those which include the results of similar trials with the sulphate of ammonia, a salt which is commonly formed whenever gypsum, either in the soil or in manure, becomes intimately mixed with the other, commonly present salts of Ammonia.

In some trials, instituted by the Turriff Agricultural Association, Mr. Jamieson, of Turriff, (*Trans. High. Soc.* 1845, p. 24,) on a grass field of perennial rye-grass—red and white clover, in 1843, obtained the following results per imperial acre:—

Manures.	Quantity.	Cost.			Green Weight, in stones.		Dry Weight, in stones.	
		£	s.	d.	st.	lb.	st.	lb.
Soil simple	. .	. .			676	0	208	0
Sulphate of ammonia	2 cwt.	2	1	8	992	0	320	0
Nitrate of soda	1½ cwt.	1	16	0	852	0	299	6
Bone dust and sulphuric acid (dry)	8 bush.	1	16	0	770	0	248	0
Gypsum	2 cwt.	0	7	4	660	0	213	10
Guano	2 cwt.	1	8	0	896	0	304	0

The following trials were made at the mill of Laithers, (*ibid.* p. 34.)

Manures.	Quantity.	Cost.			Green Weight, in stones.		Dry Weight, in stones.	
		£	s.	d.	st.	lb.	st.	lb.
Soil simple	. .	. .			1120	0	353	16
Sulphate of ammonia	2 cwt.	2	18	0	1389	2	439	6
Nitrate of soda	1½ cwt.	1	16	0	1304	0	408	0
Bone dust and sulphuric acid (dry)	8 bush.	1	16	0	1120	0	363	6
Guano	2 cwt.	1	1	0	1289	2	406	12

In some valuable experiments of Mr. John Hannam, of North Deighton. (*Trans. High. Soc.* vol. ix. p. 181.) Several saline manures were tried upon a crop of potatoes, grown on a lime-stone soil; the final results per acre were as follows:—

	Produce.		Cost.		
	Large. Boll.	Small. Boll.	£	s.	d.
Soil simple	296	50			
Sulphate of soda, 2 cwt.	233	64	0	19	0
Sulphate of soda, 1 cwt. . . . . Nitrate of soda, 1 cwt.	250	45	1	13	0
Sulphate of soda, 1 cwt. . . . . Sulphate of ammonia, 1 cwt.	305	62	1	10	6
Gypsum, 5 cwt.	243	61	0	17	0

In another experiment (*ibid.* p. 183):—

	Produce. Large. Boll.	Produce. Small. Boll.	Cost. £	s.	d.
Soil simple	117	53			
Farm-yard manure, 20 loads	165	63	6	0	0
Farm-yard manure, 20 loads; Gypsum, 5 cwt.	194	63	6	12	0
Guano, 5 cwt.	161	68	3	5	0
Guano, 5 cwt.; Gypsum, 5 cwt.	189	37	4	0	0
Farm-yard manure, 20 loads; Nitrate of soda (cubic petre), 1½ cwt.	239	53-4	7	5	6
Farm-yard manure, 20 loads; Sulphate of soda (glauber salt), 3 cwt.	163	63	7	8	6
Farm-yard manure, 20 loads; Sulphate of ammonia, 1½ cwt.	239	61	7	11	6
Farm-yard manure, 20 loads; Sulphate of magnesia (Epsom salt), 3 cwt.	176	57	7	5	6

In some applications of various manures to pease, (the partridge pea,) grown on a thin limestone soil, the following results per acre were noted by Mr. Hannam (*ibid.* p. 201):—

	Produce. Grain. Bushels.	Produce. Straw. lbs.	Cost.
Four loads of farm-yard manure, per acre	41-7	205	
Ditto, and nitrate of soda, ½ cwt.; Ditto, and sulphate of soda, 1 cwt.	47-8		
Ditto, and gypsum, 4 cwt.	51-6	254	
Ditto, and sulphate of soda, 2 cwt.	51	224	
Eight loads of farm-yard manure	41-3	256	

In some experiments of Mr. A. F. Gardener, of Barrochan, upon beans, grown upon a stiff alluvial loam, he has given the following results per quarter of an imperial acre (*Trans. High. Soc.* vol. ix. p. 242):—

Manure.	Cost. £	s.	d.	Produce. Grain. lbs.	Produce. Straw. lbs.
Soil simple				880	1720
Gypsum, 1 cwt.	0	1	6	1080	2320
Sulphate of soda, ¾ cwt.	0	4	6	840	1940
Nitrate of soda, 42 lbs.; Sulphate of soda, 42 lbs.	0; 0	6; 2	6; 5	1120	2360

The trials of Mr. John Finnie, of Swanston, upon tares, (*ibid.* p. 311,) were made in 1843, at an elevation of 600 feet above the level of the sea, a light soil resting upon green-stone rock. He found the following results per imperial acre:—

	Cost. £	s.	d.	Produce. Stones.
Soil simple				846
Gypsum, 6 cwt.	1	4	0	869
Nitrate of soda, 1 cwt. 11 lbs.	1	2	0	990
Nitrate of soda, 67 lbs.; Sulphate of soda, 1 cwt. 22 lbs.	1	4	3	1000
Sulphate of soda, 2 cwt. 44 lbs.	1	3	9¼	920
Ammoniacal salts, 1 cwt. 22 lbs.	1	3	11	1000
Bones and sulphuric acid, 4 cwt.	1	4	0	868

Dr. Wilson has given, (*Trans. High. Soc.* vol. ix. p. 340,) the chemical composition per cent. of gypsum and several other saline manures, as they usually occur in commerce:—

	Insoluble matter.	Common salt.	Water.	Pure dry salt.
Nitrate of potash (*saltpetre*) . . .	0.3	39.0	4.0	56.7
Nitrate of soda (*cubic-petre*) . . .	1.3	8.3	10	80.4
Sulphate of soda (*glauber salt*) . .	. .	. .	25	75
Sulphate of lime (*gypsum*) . . .	. .	. .	18	82
Sulphate of ammonia	. .	. .	. .	35

THE SULPHATE AND OTHER SALTS OF AMMONIA.

I have in the last section, when speaking of gypsum as a manure, explained the way in which the sulphate of lime operates in the fixation of ammonia in the soil. This process consists in the combination of the sulphuric acid of the sulphate of lime with the ammonia, and the consequent formation of sulphate of ammonia, a salt which is said to be thus *fixed* in the soil, because it is not volatile or vaporized in a temperature in which several other of the salts of ammonia are completely removed from the soil. This salt, in common with several other salts of ammonia, is a powerful fertilizer, and is one of those valuable additions to the list of the farmer's agents, for which he is indebted to modern chemistry. The value of these salts chiefly consists in the ammonia which they contain, and the ammonia is considered to be chiefly valuable as a fertilizer for the nitrogen of which it is composed. Now, ammonia consists of hydrogen 74 per cent., nitrogen or azote 26 per cent. The following is the composition of its three chief salts, which the farmer meets with in commerce. (*Farmer's Almanac*, vol. iii. p. 97.)

	Acid.	Ammonia.	Water.
Sulphate	54.66	14.24	31.10
Carbonate	45.	43.	12.
Muriate	49.55	31.95	18.50

In 1840, Liebig, when speaking of the source from whence plants obtain the greatest portion of nitrogen, combated pretty successfully the old opinion that they derived it chiefly from the atmosphere: he remarked, (*Organic Chemistry*, p. 69,) "We cannot suppose that a plant would attain maturity, even in the richest mould, without the presence of matter containing nitrogen, since we know that nitrogen exists in every part of the vegetable structure. The first and most important question to be solved therefore is, how and in what form does nature furnish nitrogen to vegetable albumen, and gluten to fruits and seeds?" After giving a variety of facts in support of the opinion, that it is ammonia which affords all vegetables, without exception, the nitrogen which enters into the composition of their constituent substances, he adds, these "give to this opinion a degree of certainty which completely excludes all other views of the matter." The way in which plants supply themselves with ammonia is thus described by Liebig, in a subsequent page of his valuable work:—"The nitrogen of putrefied animals is contained in the atmosphere, as ammonia, in the form of a gas which is capable of entering into combination with carbonic acid gas, and forming a volatile salt. Ammonia in its gaseous form, as well as all its volatile compounds, is of extreme solubility in water; ammonia, therefore, cannot remain long in the atmosphere, as every shower of rain must condense it and convey it

to the surface of the earth. Hence, also, rain water must at all times contain ammonia, though not always in equal quantity. It must be greater in summer than in spring or in winter, because the intervals of time between the showers are greater; and when several wet days occur the rain of the first must contain more of it than of the second. The rain of a thunder storm, therefore, after a long protracted drought, ought, for this reason, to contain the greatest quantity which is conveyed to the earth at one time. But all the analyses of atmospheric air *hitherto made have failed to demonstrate the presence of ammonia;* although, according to our view," says M. Liebig, "it can never be absent. Experiments made in the laboratory of Giessen, with the greatest care and exactness, have placed," continues Liebig, "the presence of ammonia in rain water beyond all doubt. It had hitherto escaped observation, because no one thought of searching for it. All the rain water employed in this inquiry was collected 600 paces south-west of Giessen, whilst the wind was blowing in the direction of the town. When several hundred pounds of it were distilled in a copper still, and the first two or three pounds evaporated, with the addition of a little muriatic acid, a very distinct crystallization of sal ammoniac was obtained. The crystals had always a brown or a yellow colour. Ammonia may also always be detected in snow water. Crystals of sal ammoniac were obtained by evaporating in a vessel with muriatic acid several pounds of snow, which were gathered from the surface of the ground, in March, when the snow had a depth of ten inches. The inferior layers of snow which rested upon the ground contained a quantity decidedly greater than those which formed the surface. It is worthy of observation, that the ammonia contained in rain and snow water possessed an offensive smell of perspiration and animal excrements, a fact which leaves no doubt respecting its origin. The products of the distillation of flowers, herbs, and roots, with water, and all extracts of plants, made for medicinal purposes, contain ammonia. The unripe transparent and gelatinous pulp of the almond and peach emit much ammonia, when treated with alkalies. The water which exudes from a cut vine, when evaporated with a few drops of muriatic acid, also yields a gummy deliquescent mass, which evolves much ammonia on the addition of lime. Ammonia exists in every part of plants, in the roots, (as in beet root,) in the stem, (of the maple tree,) and in all blossoms, and fruit in an unripe condition. Putrid urine is employed in Flanders as a manure, with the best results. During the putrefaction of urine, ammoniacal salts are formed in large quantity, it may be said exclusively, for, under the influence of heat and moisture, urea, the most prominent ingredient of the urine, is converted into carbonate of ammonia."

"Ammonia," adds Professor Johnston, (*Elem. of Chem.* p. 22,) "is naturally formed during the decay of vegetable substances in the soil. This happens either as in animal bodies by the direct union of nitrogen with a portion of the hydrogen of which they consist, or by a combination of a portion of their hydrogen with the nitrogen of the air; or, when they decompose, in contact with air and water; at the same time, by their taking the oxygen of a quantity of the water, and disposing its hydrogen at the moment of liberation to combine with the nitrogen of the air, and form ammonia. In the two latter modes, ammonia is formed most abundantly when the oxygen of the air does not gain the readiest access. Hence, in open subsoils in which vegetable matter

abounds, it is most likely to be produced, and thus one of the benefits which follow from thorough draining and subsoil ploughing is, that the roots penetrate and fill the subsoil with vegetable matter, which, by its decay in the confined atmosphere of the subsoil, gives rise to this production of ammonia."

In the section which treats of gypsum, the reader will find the results of several experiments with the sulphate of ammonia; I shall add in this place a few others in which the salts of ammonia were employed. Several of these are given in the 9th volume of the Transactions of the Highland Society.

Potato.—In some experiments of Mr. A. F. Gardener, in Renfrewshire, (*ibid.* p. 229,) with the Connaught Cups potato, top-dressed in July 1842, during a heavy rain, the following was the result of the various applications per acre:—

Manure applied.	Produce. Tons.	Cwt.
Sulphate of ammonia, 56 lbs. Sulphate of soda, 4 cwt.	13	6
Nitrate of soda, 56 lbs. Sulphate of soda, 4 cwt.	15	1
Soot, 10 bushels	10	2
Dung, 35 cubic yards	9	3

These experiments were repeated with "Rough Red Potatoes," in 1843, with the following result per acre (*ibid.* p. 236):—

Manure.	Produce. Tons.	Cwt.
Sulphate of ammonia, 1 cwt. Sulphate of soda, 1½ cwt	16	1
Nitrate of soda, 1 cwt. Sulphate of soda, 1½ cwt.	14	12
Soot, 12 bushels	13	4
Dung, 40 yards	11	16

Oats.—Of some trials with the sulphate of ammonia as a dressing for oats, by Mr. James Lumsdaine, of Lathallan, in Fifeshire, (*Trans. High. Soc.* vol. ix. p. 250,) he reports as follows:—

Manure, per Scotch Acre.	Produce. Grain. lbs.	Straw. stones.
Sulphate of ammonia, after a lea as a top-dressing, 208 lbs.	3104	448
Soil simple	2792	361
Ditto after wheat, 208 lbs.	2416	349

In those of Mr. John Finnie, of Swanston, in Mid Lothian, in 1843, (*ibid.* p. 311):—

Manure, per Scotch Acre.	Produce. Grain. qrs.	bush.	Straw. stones.
Soil simple	6	0	142
Ammoniacal salts, 1 cwt. 22 lbs.	6	6	185
Ammoniacal liquid, 65 lbs.	6	0	176
Guano, 2 cwt. 1 lb.	9	2	254

With oats, Mr. A. F. Gardener, on a medium loam soil with a subsoil of stiff yellow clay, top-dressed on the 9th of May, obtained the following return per acre (*Trans. High. Soc.* vol. ix. p. 420):—

		Produce. qrs.	bush.
Soil simple		6	3
Sulphate of ammonia	2 cwt.	7	4
Muriate of ammonia	2 „	7	2
Sulphate of ammonia 1 „, Common salt 2 „, Animal charcoal 1 „, Sulphate of magnesia 56 lbs.		8	3
Muriate of ammonia 1 „, Common salt 2 „, Animal charcoal 1 „, Sulphate of magnesia 56 lbs.		7	7
Peruvian guano	2 „	7	6
African guano	2 „	6	7

Grass.—Crop of 1843. Mr. John Finnie, of Swanston, tried various salts of ammonia as top-dressing to rye-grass, on the 13th of May—he gives the following report of the result (*Trans. High. Soc.* vol. ix. p. 314):—

Manure per Acre.	Produce. Stones.
Sulphate of ammonia, 89 lbs.	232
Muriate of ammonia, 24 lbs.	185
Ammoniacal salts, 1 cwt. 22 lbs.	235
Soot, 30 bolls	296
Nitrate of soda, 1 cwt. 11 lbs.	300
Saltpetre, 47 lbs.	167

In the trials of Mr. A. F. Gardener, of Barrochan, in Renfrewshire, (*Trans. High. Soc.* vol. ix. p. 410,) on a field of "stiff clay loam, superincumbent upon sandstone rock," top-dressed as follows, upon sown grasses, saved for hay, on the 7th of May:—

		cwt.	lbs.
Soil simple, produced of hay		26	64
Sulphate of ammonia	1 cwt. 56 lbs.	48	0
————	1 „ 8 „	44	64
Muriate of ammonia	1 „ 56 „	40	104
————	1 „ 12 „	37	80
Sulphate of ammonia 1 „, Common salt 1 „, Sulphate of magnesia 1 „		39	47
Muriate of ammonia 1 „, Common salt 1 „, Sulphate of magnesia 1 „		44	64
Peruvian guano	2 „	52	56
African guano	2 „	50	88

In another trial of Mr. A. F. Gardener, upon a field of eleven years old lea, saved for hay—the soil a good sound loam, inclining to clay, resting on clay and gravel; top-dressed April 23 (*ibid.* p. 412):—

			Produce. cwt.	Produce. lbs.
Soil simple			28	68
Muriate of ammonia	1 cwt.	56 lbs.	45	72
Common salt	2 „			
Animal charcoal	2 „			
Peruvian guano	2 „		45	96
African guano	2 „		39	96
Peruvian guano	1 „	56 lbs.	62	16
Animal charcoal	1 „			
Muriate of ammonia		56 lbs.		
Common salt		56 „		
Gypsum	1 „			
Animal charcoal	2 „		57	96
Sulphuric acid	1 „			
Carbonate of magnesia		28 „		
Sulphate of magnesia		28 „		
Muriate of ammonia		28 „		
Carbonate of soda		56 „		

CUBIC PETRE, OR NITRATE OF SODA.

This is a saline fertilizer, entirely of modern introduction. It was only about the year 1831 that it began to be imported into England. In that year 70 tons were consigned from Peru. It is chiefly procured from Iquique, where it exists in a thick stratum, at an elevation of about 3500 feet above the level of the sea. The stratum follows, according to Darwin, the margin of a grand basin or plain, which manifestly must once have been either a lake or an inland sea. (*Jour. in the Beagle*, vol. ix. p. 443.) It is composed of nitric acid 62.1 parts, and soda 37.9 parts. I have, in the detail of experiments with other manures, given in previous pages, (see pp. 136–144–5–8–9,) many trials with this salt. The quantity used per acre is usually 1¼ cwt. And, generally speaking, I have noticed it to produce the most beneficial results on light land; and this is the opinion of Mr. Everitt, of North Creake, who deems it to be "more calculated for light than for strong soils." (*Jour. R. A. S.* vol. i. p. 282.) But the evidence on this head, as I have elsewhere observed, is rather discordant. Mr. Pusey remarks, (*Jour. R. A. S.* vol. ii. p. 118,) "In this district" (Pusey, in Berkshire) "the failures with nitrate of soda have occurred upon the light sands." It failed to produce benefit in the trials of Sir Robert Throckmorton, upon "light sheep pasture," but it succeeded when applied to "two meadows resting upon clay." It failed for wheat on "a good sandy loam, upon stone brash, which had been for many years in a state of high cultivation, and had been three years in grass." Mr. Harris, of Hinton, also found on a farm, "chiefly a free loam, that on one lot only was any visible effect whatever produced: this particular spot was pasture, consisting of a thin layer of sandy loam upon a heavy clay." (*Ibid.* p. 119.) In Mr. Pusey's own experiments with this salt as a top-dressing, on some stone brash land with spring wheat, it failed to produce a good result; but in another trial, "on two wheat fields of 20 acres, the soil of which" (the Oxford clay) "is as strong and unmixed a clay as can be found," it succeeded very well, the outlay on the nitre being more than repaid by the increase of the crop. (On examining the wheat, however, the wheat produced on different portions of this field, it was noted that four bushels of the seed, from the portion dressed with nitre,

yielded 241 lbs. of flour, but that four bushels without nitre produced 251 lbs.) Mr. Anderson thinks that "on strong land" it did harm to turnips. (*Ibid.* p. 125.) At Aske, on a meadow, "a good loamy soil, well drained, with sandy stone and limestone below," it produced very good results. It appears also to answer very well on the chalk soils near Guildford. Mr. Drewitt remarks of these, "The chalk I cultivate is a very dry rubbly chalk, without any mixture of loam, and but little other mould; and on this soil it had no effect upon turnips, though for every other crop it was admirable." He adds, however, "Where it had no effect upon the turnips last season, and where, of course, they were inferior, its effect on the succeeding crop of barley was very great, it was superior to every other part of the field. (*Jour. R. A. S.* vol. ii. p. 127.) After considerable inquiry, Mr. Dewdney, of Dorking, is of opinion (*ibid.* p. 128) "that on strong ground, or land in a high state of cultivation, it is dangerous to use it for wheat, there being a greater probability of the crop blighting;" but he commends its use "as a top-dressing on the Swede and turnip crops, particularly on light land." Mr. Barclay, of Leatherhead, remarks, "My farm is situated on the confines of the clay and chalk formations: the soil of the western part is mostly of a heavy description, with a subsoil of stiff clay. The experiments made with this portion, whether upon corn or grasses, have been unsuccessful, while those which have been made on the light lands, with chalk subsoil, have, with few exceptions, been attended with beneficial results. Mr. Grey, of Dilston, thinks, from the result of his observations, (a conclusion in which I am very much disposed to concur,) that the soil has little or no influence in the matter, but rather that it is "a stimulus to the plants." (*Ibid.* p. 135.) At present, at any rate, the question is encircled with doubts and difficulties; and certainly, as Mr. Pusey well remarks, "the nitrate of soda appears most capricious in its operations; but it is not, of course, nature who is variable, but we who are ignorant." In some comparative experiments of Mr. Dugdale, "on a stiff clayey field manured with lime in the autumn, the produce of half an acre of wheat was found to be, when manured with

Nitrate of soda	18 bush.	1 peck.
Nitrate of potash (saltpetre) . .	17 "	2 "
Soot	17 "	1 "
Lime only	16 "	0 "

MANURES APPLICABLE BY THE DRILL.

The economy of manures has, within the last few years, been very materially promoted by the preparation and extended use of various fertilizers in so dry a state as to admit of their ready and very advantageous application by the drill. This, as a natural result, has led to a corresponding improvement in the construction of the common drill, an instrument of so powerful and useful a description that, as I have in another place remarked, it only requires from the English farmer a little more careful consideration of its powers, and of the value of the numerous fertilizers which are now so evenly, and so readily, deposited by its machinery on all soils, (varying too with their nature,) and moreover on the most uneven grounds, to insure their universal adoption. To this end, although much has been accomplished within the last year or two, yet much still remains to be effected; for in some districts, such as on the gravels of Bedfordshire, and even on the sands of Norfolk, the manure drill is almost an unemployed machine. This drill is formed very readily, by merely adding to the common corn drill (an operation

which any husbandman can perform) "a manure box," and a simple yet accurately working apparatus for delivering the manure, which in the best drills it does with great evenness, and in quantities, varying as "the slip" is placed, from six to eight bushels per acre: and in these drills a very important improvement has been made within the last few years; for, by the use of separate coulters for manure and seed, the manure is now deposited according to the mode preferred by the cultivator, not only from two to three inches deeper in the ground than the seed, but from ten to twelve inches in advance of it, so as to give the soil time to cover the manure before the next coulters deposit the seed; whereas, on the old plan of depositing the seed and the fertilizer together down one pipe, the evil was liable to arise with some of the more powerful artificial manures, such as guano, that the seed and the manure were too close together, and the manure was not always in what is commonly its best position *under* the seed.

Admitting the truth of the experiments which have been made with the manure drill, that one-half of the quantity of the organic manures usually spread on the land is sufficient, when applied by it in immediate contact with the seed, what a field is thus opened for the manuring of much larger breadths of land than has hitherto been deemed possible. The complaints of the deficiency of manures, which are so often prevalent with farmers, need then no longer be heard. Their crops will be properly nourished, and the manure applied with them will be not only bestowed in the most scientific manner, but it will lead to other improvements; it will enable the farmer to mix his manures, according to the nature of his soil and his crop, with much more facility than at present; he will then study, not merely the economy to be regarded in its distribution, but also its quality, or chemical composition, and to what soils the manure is best adapted.

If I were asked to produce any evidence of the extreme difficulty with which agricultural improvements, even of the most undoubted value, are introduced, I might instance the manure drill, whose progress has indeed been slow, for it has shared the fate of very many other scientific efforts, been zealously opposed by the ignorant, neglected by the indolent, and ridiculed by the bigoted farmer, as an innovation upon the good old system of the days of the happy patriarchs of agriculture, when the earth brought forth its fruits in abundance, and the very seeds were not sown by man. But even here this solitary argument of the clinger to old customs fails; for the Chinese (the most expert of farmers)* and the cultivators of Japan and of Arabia have drilled and dibbled in their seed from time immemorial. The natives of the Carnatic do the same; and, after they have thus deposited their seed, the Hindoos use a kind of subsoil plough, which passes under, and loosens the soil, to the depth of about eight inches, under about three drills' breadth at a time †. And so prejudiced are the natives of those

* Sir George Staunton, in his account of Lord Macartney's Embassy to China, says, (vol. ii. p. 375,) "Near Sanchoo, wheat was perceived growing for the first time in China. It was, though on a dry sandy soil, where no rain had fallen for the three preceding months, looking remarkably well. It was very neatly sown in drills, or dibbled, according to the method used of late in some parts of England. A gentleman of the embassy calculated that the saving of the seed alone in China by this drill husbandry, which would be lost by that of broadcast, would be sufficient to maintain all the European subjects of Great Britain."

† In a communication to the Board of Agriculture, dated at Junacondah, December 31, 1795, Captain Halcott says, "The drill-plough, I find, is in general use here, and has been so, time immemorial, in the culture of all grain, (except horse grain,) and also of tobacco, cotton, rice, and the castor-oil plant."—(*Com. Board of Ag.* vol. i. p. 355.)

empires, too, in favour of the customs of their ancestors, so rarely do they introduce new modes of cultivation, that it has been hence very reasonably concluded, that the drill system, so far from being entitled to the appellation of "the new husbandry," ought rather to be classed with those branches of the sciences which degenerated, or were lost in the dark ages*.

It is usless to search in the works of Jethro Tull for any recommendation of the drill as a means of applying manure; for all Tull's arguments and experiments are directed to proving that the application of manure, of any kind, is utterly needless.

The merit of the introduction of the drill to *general notice* in England, is, however, to be ascribed, in a very great measure, to Jethro Tull. Yet Jethro Tull certainly thought himself *the inventor;* for he tells us so very clearly, in the preface to the first edition of his "Horse-Hoe Husbandry," published in 1731, and even whence he derived the hint for his drill; he says, "When I was young, my diversion was music; I had also the curiosity to acquaint myself thoroughly with the fabric of every part of my organ; but as little thinking that I should ever take from thence the first rudiments of a drill, as that I should ever have occasion for such a machine, or practise agriculture, for 'twas accident, not choice, that made me a farmer." But he was certainly not the originator of the idea of thus applying the seed; for, nearly a century before his time, John Worlidge ineffectually, in 1669, laboured hard to draw the English farmer's attention not only to the drill, but to *the manure drill* also. And little can be now added to what, 175 years since, honest John Worlidge urged in its favour, when he said, after describing the seed-drill, "By the use of this instrument, also, you may cover your grain or pulse with any rich compost you shall prepare for that purpose, either with pigeons' dung, dry or granulated, or any other saline or lixivial substance made dispersable, which may drop after the corn and prove an excellent improvement, being in the same furrow with the corn, whereas in the other vulgar way a great part thereof comes not near it."

Worlidge was well supported by Evelyn, who, in a communication to the Royal Society, dated in February, 1669, (*Trans. Roy. Soc.* vol. v. p. 1056,) urged the advantages of a drill-plough, which, first invented in Germany, had thence been introduced at Madrid under the auspices of the Spanish monarch, and had been forwarded from Spain by the Earl of Sandwich, as the invention of a Don Leucatilla. It is there described as "the Spanish sembrador, or new engine for ploughing, and equal sowing all sorts of grain, and harrowing at once." Leucatilla saw very clearly the errors of the broadcast system: he observed, "*Even at this day* (1669) all sorts of seeds are sown by handsful, heedlessly and by chance, whence we see corn sown in some places too thick, in others too thin."

Under the heads of Guano, Bones, Super-phosphate of Lime, &c., the young farmer will find the details of various experiments, in many of which fertilizers were applied to the soil (mixed in case of need with ashes, &c.) by the manure drill. In this place I will chiefly confine my attention to the use of those artificially prepared manures which are manufactured in various parts of England for the farmer's use. Mr.

* The first drill introduced into Europe, seems to have been the invention of a German, who made it known to the Spanish court in 1647.—(*Hartes' Essays on Husbandry.*) The Roman farmers endeavoured to attain the advantages of row-culture by ploughing in the seeds.

Compton tried several of these upon Swede turnips in 1841. (*Jour. R. A. S.* vol. ii. p. 270.) He found in eleven experiments—

			Produce of Turnips. cwt.	lbs.
5 cart-loads of cow manures to $\frac{1}{4}$ of an acre, rows	27	inches .	79	0
5 " horse " "	27	"	80	0
5 " cow " "	18	"	87	73
5 " horse " "	18	"	101	0
5 bushels of half-inch bones "	27	"	73	82
5 " " " "	18	"	89	12
$6\frac{1}{4}$ " Poittevin's manure "	27	"	74	26
$6\frac{1}{4}$ " " "	18	"	82	0
5 " with soot and ashes	18	"	90	0
Bone refuse, with soot and ashes, cost 16*s.*	18	"	80	0
Grass and weeds, 5 cart-loads put in green	18	"	64	0

And, when speaking of the application of the super-phosphate of lime to land, Mr. Pusey remarks, (*ibid.* vol. vi. p. 328,) when alluding to the necessity of returning to the soil the chemical ingredients withdrawn from it by the crop, "according to Boussingault a crop of four quarters of wheat to the acre draws from that acre at least 30 lbs. of phosphoric acid. But, further, a direct experiment has proved its success. This was made by Mr. Pemberton Leigh upon wheat, and published in our Journal of last year, but it is so much in point that I must shortly give it again."

One Acre.	Cost. £	*s.*	*d.*	Yield of Wheat. Bushels.	Incr. per Acre.
No manure	...			29	...
Rape dust, 5 cwt.	1	12	6	38	9
Urate of the London Manure Company, 6 cwt.	1	12	6	38	9
Dung, 30 loads	4	10	0	40	11
Guano, $3\frac{1}{2}$ cwt.	2	4	0	40	11
Super-phosphate of lime, 6 cwt.	2	4	9	53	24"

In some experiments with carrots, by the Rev. V. L. Harcourt, of Chichester, (*Agricultural Gazette*, 1844, June 1,) the following was the quantity, cost, and return, from the use of various manures:—

Quantity of Manure.	Cost per acre. £	*s.*	*d.*	Produce per acre. tons.	cwt.	lbs.	Difference. tons.	cwt.	lbs.
3 cwt. of urate	0	15	0	17	3	32	+ 6	6	52
1 cwt. of nitrate of soda . . .	1	0	0	11	12	82	— 0	2	102
21 gallons of Poittevin's, 36 . .	0	4	5	11	18	62	+ 0	2	102
7 cwt. of bone-dust	1	6	3	12	4	62	" 1	8	102
1 cwt. of sulphate of ammonia .	0	17	0	11	12	82	" 1	9	10
$2\frac{1}{2}$ cwt. of guano	1	10	0	11	1	11	" 1	9	10
Farm-yard dung	0	12	0	14	8	0	" 1	9	10
21 gallons of Poittevin's, 170 .	0	9	10	12	18	102	" 1	14	102
21 galls. of Clarke's desic. compost	0	4	10	13	13	52	" 2	6	61
3 cwt. of guano	1	16	0	12	13	10	" 3	4	0
1 cwt. of oxygen alkali . . .	1	8	0	13	10	61	" 3	9	92
$1\frac{1}{2}$ cwt. of guano	0	18	0	15	14	22	" 4	16	3
1 cwt. of ammonia alkali . . .	2	2	0	11	6	103	" 5	4	82
6 cwt. of guano	3	12	0	14	10	103	" 5	7	73

LIQUID MANURE*.

Considerable progress has been made, during the last few years, in the more general collection and distribution of liquid manure; a still greater extent of benefit would be derived, if the farmer paid more attention not only to the collection, but to the *quality* of the liquid manure he carries on to his land. In Belgium and other continental states, where liquid manure is very extensively and profitably applied, great care is bestowed upon its preparation. They are not content to employ some merely discoloured water, but they systematically strengthen this with cow-dung and other matters. "The best proportion of the mixture is three-fourths of water to one-fourth of excrement, if the cattle be fed on corn; but, if in course of fattening, one-fifth of excrement to four-fifths of water will be sufficient." (*Johnson on the Fertilizers*, p. 197.) Now, how seldom does the quantity of solid matters in the liquid drainage of the farm-yard approach this proportion, will be readily believed. I have already given, under the head "Farm-yard Manure," the composition of a specimen of such drainage matters, and also the analysis of liquid manure in different states, by which the young farmer will perceive the advantage of subjecting the liquid manure to a *putrefactive fermentation* previous to its application. The well-known effect produced upon grass by the use of the Edinburgh town drainage has recently prompted a similar attempt, with the best promise of success, in the case of the London sewerage, and there is little doubt that the same improvement might be extended to various portions of the kingdom with the best practical results. It is needless to urge the value of such applications of liquid manure. Every holder of such meads, or even of a water meadow, will confirm the rapidly forcing nature of such fertilizing matters; and this effect is not confined to its application to grass; the late Mr. T. A. Knight proved them to possess a similar power when applied to fruit-trees:—

"I have shown in a former communication," said this able vegetable physiologist, "that a seedling plumstock, growing in a small pot, attained the height of nine feet seven inches in a single season; which is, I believe, a much greater height than any seedling tree of that species was ever seen to attain in the open soil. But the quantity of the earth which a small pot contains soon becomes exhausted relatively to one kind of plant, though it may be still fertile relatively to others, and the size of the pot cannot be changed sufficiently often to remedy this loss of fertility; and, if it were ever so frequently changed, the mass of mould which each successive emission of roots would inclose must remain the same. Manure, therefore, can probably be most beneficially given in a purely liquid state; and the quantity which trees growing in pots have thus taken, under my care, without any injury, and with the greatest good effect, has much exceeded every expectation I had formed."

An attempt has been recently made, in the case of the Edinburgh sewer-watered meads, to deprive the holders of the right to use the sewerage for the purposes of irrigation. "The owners," says Mr. Chadwick, "treat the proposal to divert the contents of the sewers as being, in fact, a proposal to deprive the city of the milk and butter yielded by more than 3000 milch cows, and the markets of the meat from their carcases; that, in fact, the grass which, in virtue of irriga-

* See *British Husbandry*, vol. i. p. 270.

tion, these meadows produce, supports in Edinburgh 3300 cows, and in Leith 600 cows during the season." (*Report on the Sanatory Cond. of the Lower Classes*, 1842, p. 50.)

To those who, in the employment of liquid manure, object to the excrements of animals, the use of soot will be found at once easy and economical. It appears from the statements of Mr. Robertson, (*Gard. Mag.* vol. ii. p. 18,) that this manure is highly advantageous, when mixed with water in the proportion of six quarts of soot to a hogshead of water. "Asparagus, peas, and a variety of other vegetables," says this intelligent horticulturist, "I have manured with this mixture, with as much effect as if I had used solid dung; but to plants in pots, particularly pines, I have found it admirably adapted: when watered with it, they assume a deep healthy green, and grow strong and luxuriant."

The Chinese, who are remarkably skilful in the management of manure, are particularly careful not to waste the smallest portions; and, according to Sir George Staunton, they prefer the dung of birds to that of all others, and next to that night-soil, which they apply in a *liquid* state. "Their first care," says our author, "is to construct large cisterns, free from absorption, to contain, beside this manure, and soil of every kind, all sorts of vegetable matter, as leaves, or roots, or stems of plants; with all these they mix as much animal water as can be collected, or common water, to dilute the whole; and in this state, generally in the act of putrid fermentation, apply it to the ploughed or broken earth." The Chinese husbandmen, we learn from the same authority, always steep their seed-wheat in liquid manure, until it swells and germinates, which they say hastens the growth of the plants, and at the same time defends them from the attacks of insects; they also apply liquid manure to the roots of plants and fruit-trees. And how grateful liquid manure is to vines, &c. is well known to most English gardeners. The immense produce of grapes by the great Hampton Court vine, has been supposed to be mainly owing to its roots having penetrated to an adjoining sewer belonging to the palace; and the roots of the nearly equally celebrated vine at Valentines, in Essex, are known to reach an adjoining stagnant canal.

SECTION VIII.

THE LIVE STOCK OF THE FARM.

THE FOOD OF ANIMALS *.

VERY considerable advances have been made, in the last few years, towards a more perfect and a more practically useful knowledge of the most profitable mode of feeding live stock. In no portion of agriculture has science been applied to the pursuits of rural life with more success in explaining the doubtful practices, and in pointing the way to the more useful practice of farming economy, than in this. The nature of food—the influence of shelter—of temperature, and of quietude—has been laboriously illustrated by the chemist, the physiologist, and the scientific farmer, with very considerable success. That vegetable substances contain animal matters ready formed, was a suspicion

* *Supplementary Note, for vol.* i. *p.* 148.

which was entertained in a confused shape by more than one of even the early Greek philosophers, but it was reserved for the modern chemist to prove the truth of the supposition. This has been thus explained by Dr. Lyon Playfair (*Jour. R. A. S.* vol. iv. p. 216):—

"All vegetable food has been found to contain a peculiar substance, which, though it differs in appearance and in form, according to the source from whence it is obtained, is in reality the same body. It has received the name of gluten or albumen, and is precisely identical, in chemical composition, with the albumen obtained from the white of an egg. This substance is invariably present in all nutritious food. Chemists were surprised to discover that this body never varies in composition; that it is exactly the same in corn, beans, or from whatever plant it is extracted. But their surprise was much increased when they remarked that it is quite identical with the flesh and blood of animals. It consists, like the latter, of carbon, hydrogen, nitrogen, and oxygen, and in the very same proportion in 100 parts. By identity in composition is not meant a mere similarity, but an absolute identity; so much so, that if you were to place in a chemist's hand some gluten obtained from wheat flour, some dry albumen procured from the white of an egg, a fragment of the flesh of an ox or of a man, or some of their dried blood, and request him to examine their difference, he would tell you, strange as it may appear, that they are precisely the same, and that with all the refinements of his science he was unable to detect any essential difference between them. There is much difference, indeed, in external appearance and in structure, but in their ultimate composition there is none." To render this more obvious, I subjoin the composition of these various substances, as obtained by different chemists, who executed their analyses without any knowledge of the results obtained by the others:—

	Gluten from Flour. Boussingault.	Casein from Pease. Scherer.	Albumen from Eggs. Jones.	Ox Blood. Playfair.	Ox Flesh. Playfair.
Carbon . .	54.2	54.138	55.000	54.35	54.12
Hydrogen .	7.5	7.156	7.073	7.50	7.89
Nitrogen .	13.9	15.672	15.920	15.76	15.67
Oxygen . .	24.4	23.034	22.007	22.39	22.32
	100.0	100.00	100.00	100.00	100.00

These analyses do not differ from each other more than the analyses of the same substance usually do. Thus we are led to the startling conclusion, that plants contain within them the flesh of animals ready formed, and that the only duty of animals subsisting upon them is to give this flesh a place and form in their organism. When an animal subsists upon flesh, we find no difficulty in explaining its nutrition; for the flesh being of the same composition as its own body, the animal, in a chemical point of view, may be said to be eating itself; nor, with a knowledge of this identity of vegetable albumen with flesh, is there any difficulty in comprehending the nutrition of vegetable feeders.

Plants, then, in reality, form the *flesh* of animals; and the latter merely appropriate it a place in their organism.

It follows, then, as a conclusion, that the analysis of any vegetable substance pretty accurately indicates its nutritious powers. "It has been shown by many laborious chemical researches," to use the words of Dr. Playfair, "that there are two kinds of food. The first, which contains nitrogen, is exactly of the same composition as the principal tissues of

the human body, and is the only substance which can supply the waste of these tissues. The second kind of food is that destitute of nitrogen, such as starch, gum, and sugar, all of which are destined for the support of respiration and consequent heat of the animal. The latter kind of food, when in excess, is converted into fat, but never into muscle. The increase of flesh in an animal consists in two changes of the matter of the food, without any alteration in its composition. The albumen or nitrogenous constituent of the food is first converted into blood, without decomposition, and the blood is afterwards converted into flesh. In order to show that the transformation is actually effected without change, we have only to refer to the following results of the analysis of vegetable albumen of ox blood, and of flesh:—

	Vegetable Albumen.	Ox Blood.	Flesh.
Carbon . .	55.160	54.35	54.12
Hydrogen .	7.055	7.50	7.89
Nitrogen . .	15.996	15.76	15.67
Oxygen . .	21.18	22.39	22.32

"As muscle then is formed only by the albumen or gluten of the food, which albumen is in reality flesh itself, we can ascertain the comparative value of food, as far as the production of muscle is concerned, by estimating the exact quantity of the nitrogenous constituent of the food. The following table," continues Dr. Playfair, " contains the approximative, *though not perfectly accurate, information relative to the* value of food for the support of respiration and production of fat:—

100 lbs.	Albumen. lbs.	Unazotized Matter. lbs.	100 lbs.	Albumen. lbs.	Unazotized Matter. lbs.
Flesh	25	0	Oats	11	68
Blood	20	0	Barleymeal .	14	68½
Beans	31	51½	Hay	8	68½
Peas	29	51½	Turnips . . .	1	9
Lentils	33	48	Carrot . . .	2	10
Potatoes . . .	2	25	Red-beet . .	1½	8½

That *fat* exists ready formed in various vegetable substances, has been proved by careful chemical examination. Thus, according to Liebig, hay contains 1.56 per cent., and maize 4.67 per cent. of fat. Braconnot found 1.20 per cent. in peas, while Fresenius got 2.1 per cent.; and in lentils 1.3 per cent. Vogel obtained 2.00 per cent. of fat in oats; Liebig 0.3 per cent. in dry potatoes; and Braconnot 0.13 per cent. in rice, although, in another variety, Vogel states that he detected 1.05 per cent. The substance here called fat is in reality a waxy or resinous body, and not tallow, except in a few instances.

The inquiry relating to the mode in which animal heat is produced, and the proportion of food required to maintain it, is a subject full of interest to the farmer. It is a question intimately connected with the practices of sheltering cattle and of feeding live stock in places where the temperature is much more considerable than in the open air. The chief results of this research are thus given by Dr. Playfair, (*Jour. R. A. S.* vol. iv. p. 217:)—

" The average temperature of the bodies of our cattle is about 100°, or more than 40° higher than the ordinary temperature of this climate. Hence there must be some provision in the animal body to sustain the heat, which is absolutely necessary for the performance of the organic functions. The air, being so much colder than the body, must constantly

withdraw from it heat, and tend to lower its temperature. Whence, then, comes the fuel for the production of the heat?

"The fuel consists of those ingredients of food from which nitrogen is absent; they all contain carbon and the elements of water. We know that oxygen is continually exhaled in the air we breathe, and that it is never again expired as such. Expired air consists of carbonic acid, a gas composed of carbon and oxygen. In the body, therefore, the oxygen has united with carbon; *or it has produced the very gas which is obtained by burning a piece of charcoal in the open air.* Now the heat generated by the combustion of the carbon in the body must be exactly equivalent to that produced by burning the same amount in the atmosphere."

Experiments have taught us, that the average quantity of carbon in the food of an adult man amounts to 14 ounces daily. By the combustion of this quantity 197,477° of heat are produced, and this is amply sufficient to account for the heat of the human body.

The experiments of Boussingault show, that a cow breathes out about 70 ounces of carbon daily, and from this we calculate that 987,385° of heat must be produced in the body of a cow in the space of twenty-four hours. These calculations will at once prove that there is little difficulty in accounting for the heat of the animal body.

But, as the heat of the animal body is the same in all regions, it is obvious that the quantity of fuel (food) necessary to sustain the constant temperature of the body must vary according to the nature of the climate. Thus less food is required for this purpose in India, where the temperature of the external air equals that of the body, than in the polar regions, in which it is very many degrees lower. But a beneficent Providence has arranged the produce of different countries so as to meet the exigencies of the climate. The fruits, upon which the inhabitants of warm countries love to feed contain only 12 per cent. of carbon, while the train-oil enjoyed by the inhabitants of arctic regions contains above 70 per cent. of the same element.

It has been shown that the food of various countries is more or less combustible, according to the temperature of the climate; and proofs were adduced that the amount of the food consumed varied also according to the temperature. The animal body is a furnace which must be kept up to a certain heat in all climates. This furnace must, therefore, be supplied with more or less fuel according to the temperature of the external air. If then in winter we wish to retain the vital functions of our cattle in a proper degree of activity, we must keep up the heat of their bodies. This we may do in two ways. We may either add more fuel (food) to the furnace, or we may protect their bodies from the cold. Warmth is an equivalent for food, which may thus be economised. As a proof of the view I have now given, I will cite the following experiment which was made by the Earl of Ducie at Whitfield farm.

One hundred sheep were folded by tens in pens, each of which was 22 feet in length by 10 feet in breadth, and possessed a covered shed attached to it of 12 feet in length by 10 feet in breadth. They were kept in these from the 10th of October to the 10th of March. Each sheep consumed on an average 20 lbs. of swedes daily. Another hundred were folded in pens of a similar size, but without sheds attached. They were kept during the same time, and their daily consumption of swedes amounted to 25 lbs. each. Here the circumstances were precisely similar with respect to exercise, the only difference being that the first hundred sheep had sheds into which they might retire, and thus be partially protected from the cold.

This partial protection was equivalent to a certain amount of food, and consequently we find that the sheep enjoying this protection consumed one-fifth less food than those sheep which were left entirely exposed to the cold. In the last case the consumption of the additional food arose wholly from the necessity of adding more fuel (food) to the furnace of the body, in order to keep up its normal temperature. This was proved from the circumstance, that those sheep which enjoyed the protection had increased 3 lbs. each more than those left unprotected, although the latter had consumed one-fifth more food.

The influence of warmth in reducing the consumption of food has been examined experimentally by other farmers, who pretty well agree in the conclusion, that warmth is, to a considerable extent, a substitute for food. It is true, that in the experiments with sheep the results have been somewhat discordant, but, as I have elsewhere had occasion to remark, this has arisen in many cases from inattention to other injurious influences to which these animals were exposed. Warmth is not only essential to their health and fattening progress, but this must be a *dry* and a *wholesome* warmth. To confine the sheep, as is sometimes done, over putrefying masses of fold, shed, or farm-yard dung, in an atmosphere saturated with fumes of ammonia and the gases of putrefaction, is to substitute one drawback upon the health and comfort of the animal for another, which produces a greater evil than cold. The sheep, in a state of nature, carefully avoids all these things; it leaves to the ox the deep rank-growing grasses of the damp lowland pastures. It carefully seeks its food and its habitation on the highest elevations, amid dry rocks and heath-producing soils, far away from all great masses of decomposing organic matter. The domestic sheep of our inclosed lands, by always occupying the most elevated portions of the field, clearly indicates that its natural instinct in this respect is still unchanged by all the efforts of the breeder. Follow, then, the sheep from his upland pastures, in the clear, dry, warm climate of Asia, and view him placed in our cold temperature, in a warm shed it is true, but with the floor of that shed covered for a depth of many inches with a mass of putrefying dung, and then let us ask ourselves, "Is this the way fairly to test the advantages of shelter and of warmth to the domestic sheep? Is this the way to fairly try the economy of raising the temperature of the atmosphere in which it is placed?" The Rev. A. Huxtable saw this in its true light, when he commenced his trials. He tells us, in his valuable little paper, (*Jour. R. A. S.* vol. vi. p. 242,) "Having observed that sheep in wet weather on our downs always select the most beaten roads for their bed, it occurred to me that not only when under sheds should they lie on boards, according to your own experiment, but also that the courts to which they have daily access whilst their houses are being cleaned should be covered, not with soft litter, but with hard chalk or sand, or other materials to form a solid bottom. My little yards attached to the sheds are floored with a sort of asphalte made of chalk beaten small, covered with gas-tar and sand. In constructing sheds for my sheep I have kept in view the strictest economy; and I venture to send these minute details, which I hope will serve to prove that the protection of sheep from the inclemency of the weather is within the reach of every tenant farmer. Each of these sheds contains about 50 sheep. They are erected on a very simple plan: a couple of fir poles, 12 feet long, are nailed together at the top; their extremities, at a distance of 15 feet, are driven into the ground; another couple, 10 feet distant, are united with this, and held firm by a ridge-pole nailed into and lying between

the tops of the fir poles. Side pieces are nailed parallel to the ridge-pole, and small hazel-wood is interlaced so as to support the thatch, which a labourer ties on with tar-twine. The thatch in front and behind reaches to about 3 feet from the ground; behind, a bank of turf is raised to meet the thatch; the front is guarded by a hurdle, moveable at pleasure, to allow the sheep to go into the court, which is of the same size as the shed. It is important that both ends of the shed should be protected with bavins only, which will secure a free ventilation, yet keep out rain. My sheds, about 50 feet long, (not charging the straw,) cost about 41*s.* each.

"These sheds are covered with 1-inch boards, separated (each strip from the other) by ¾ inch intervals. The cost of the timber and mode of preparing the floor were as follows:—White pine timber was used for its cheapness, being 1*s.* 3*d.* the cube foot, which would therefore give eleven 1-inch boards. On account of the particular width of the logs which I bought, the board was sawn into pieces 7 inches broad and 1 inch thick. These, for economy, are hand-sawn into three parts, and are nailed upon joists at a distance of ¾ inch. By this plan nearly one-third of timber is saved; so that each sheep, requiring 9 feet of space, lies actually on 6 feet of 1-inch board. The cost of timber for joists, nails, and carpenters' work, raises the total expense of placing the sheep on boards to 1*s.* 4*d.* per head. Instead of sleepers I used small blocks, 6 inches thick, to keep the rafters from direct contact with the manure. The boards are put together into frames about 10 feet by 4, so that they may easily be taken up by one man. Beneath the boards the floor, excavated 8 or 9 inches, is puddled and made water-tight, and covered with 6 inches of sawdust, burnt clay, or good dry mould. This receives and absorbs the manure which falls, or is swept below twice a day. The boards, after sweeping, are watered with a solution of 3 lbs. of sulphate of iron, which instantaneously removes the odour not only of the ammonia, but of the more offensive sulphuretted hydrogen. The boards should be laid perfectly flat, to prevent the sheep slipping about. The sheep are fed under the sheds, not in the courts. The results of this arrangement have been most successful, both in the health and *well-doing* of the sheep.

"It is true that I have lost four head, which seem to have died from apoplexy; but I lost the same number in the flock which were at large, and treated in the usual manner. Though I have had more than 300 Southdowns so shedded, some of them longer than five months, yet I have never seen any instance of lameness, even in the least degree.

"Their food consists of turnips, for the last fortnight only of swedes; half a pint per day (never more) of oats or peas; with straw cut into chaff, over which ground linseed has been poured, mixed with boiling water.

"I regret that I cannot send the important statistics of weight and improvement under this regimen. During one month the sheep were weighed, and found to have increased about 3 lbs. per week on an average; that is, ten were selected and weighed which seemed fairly to represent the flock, and they had made this improvement. The illness of my bailiff stopped these calculations; but the general issue will be allowed to be satisfactory, as more than half have been sold which in twelve weeks have paid 13*s.* a head.

"Leaving out of the account both the injury which in bad seasons my clay-lands would have sustained by the treading of the sheep, and the value of the rich manure saved under shelter, (its gases fixed by the

facts, it becomes a money question as to the value of particular kinds of food for the support of the frame. We know how much of flesh-giving principle each variety of food contains, and therefore we can at once estimate how much of each it will be necessary to consume to obtain one pound of real nutriment, and what the cost of that pound will be to the consumer. The following table is constructed on this principle, but as prices vary in different localities, these may be altered to suit the peculiar case: in the table, they are given at the rate at which the respective substances might be purchased in London under favourable circumstances.

Quantity of Food necessary to produce 1 lb. of Flesh, and the Money-Cost of its production.

25 lbs.	of	milk furnish 1 lb. of flesh, and cost . .	0	3	1
100	„	turnips „ . .	0	2	9
50	„	potatoes „ . .	0	2	1
50	„	carrots „ . .	0	2	1
4	„	butcher's meat, free from fat and bone, furnish 1 lb. of flesh, and cost . .	0	2	0
9	„	oatmeal „ . .	0	1	10
$7\frac{1}{10}$	„	barleymeal „ . .	0	1	2
$7\frac{4}{10}$	„	bread „ . .	0	1	2
$7\frac{4}{10}$	„	flour „ . .	0	1	2
$3\frac{1}{2}$	„	peas „ . .	0	0	7
$3\frac{2}{10}$	„	beans „ . .	0	0	$6\frac{1}{2}$

Let us look at the various kinds of food with reference to their value as fuel, and we shall perceive that the potato takes its proper rank. Such a table as the following is, however, a mere rough approximation, for the carbonaceous matter or fuel is of very various kinds, and some of them give more heat than others by their combustion. The table, therefore, must only be taken for as much as it is worth, a rough approximation to truth.

Table showing the Approximative Value of various kinds of Food as Fuel to sustain Animal Heat.

			£	s.	d.
4 lbs.	of	potatoes contain 1 lb. of carbonaceous fuel, and cost	0	0	2
10	„	carrots „ „	0	0	2
$1\frac{1}{2}$	„	flour „ „	0	0	$2\frac{8}{10}$
$1\frac{1}{2}$	„	barleymeal „ „	0	0	3
$11\frac{1}{10}$	„	turnips „ „	0	0	$3\frac{3}{4}$
$1\frac{1}{2}$	„	oatmeal „ „	0	0	$3\frac{3}{4}$
$1\frac{9}{10}$	„	beans „ „	0	0	$3\frac{3}{4}$
$1\frac{9}{10}$	„	peas „ „	0	0	$3\frac{8}{10}$
2	„	bread „ „	0	0	4
$11\frac{9}{10}$	„	milk „ „	0	1	5

It will not be unattended with benefit if we contrast these valuable scientific researches upon the cost of production with the results of the trials of a practical Scotch farmer.

From some careful experiments of Mr. Bruce, of Waughton, in East Lothian, (*Trans. High. Soc.* 1846, p. 375,) with linseed cake and other substances in sheep feeding, he concludes that "mutton can be produced at a lower rate per lb. upon liberal use of foreign keep along with turnips, than upon turnips alone, taking of course the increased value of the manure into account;" that of this foreign keep "linseed is the most valuable, and beans the least so; but that the mixture of both forms a

useful and nutritious article of food." In his trials 95 Cheviot ewes were divided into five lots, and inclosed, and fed with turnip tops and the following substances, upon portions of equally sheltered grass land. Lot A consisted of 15 ewes, B, C, D, and E, of 20 each.

Lot.	Weight. Oct. 21. lbs.	Weight. Dec. 23. lbs.	Average Consumption of each Sheep per Week. oz.	Cost of Production per lb. oz.
A	1839	2008	56½ Linseed. 4¼ Beans.	46½ Linseed.
B	2401	2603	113¼ Linseed cake.	101 Linseed cake.
C	2382	...	95½ Beans and Linseed.	59 Beans and Linseed.
C	...	2657	157¼ Poppy cake.	106 Poppy cake.
D	2404	2557	113¼ Beans.	133¼ Beans.
E	2417	2736	100 Beans and Linseed.	56¼ Beans and Linseed.

THE VENTILATION AND CLEANLINESS OF SHELTERED ANIMALS *.

The injurious effects of the ill-ventilated and dirty buildings in which horses and other live stock are often kept, are seldom regarded with a sufficient degree of attention. These effects are, unfortunately, not only certain, but they are commonly not evinced with sufficient rapidity: cause and effect are here not so closely apparent as to induce remedial measures. The owner, therefore, with his attention closely directed to the *warmth* of the animal, too often loses sight of the injurious effects of that *unwholesome* warmth upon the health of the animal. And yet, as I have had occasion to observe some time since, it would be a rational anticipation that when the owner was thus endeavouring to place his domestic animals in a temperature which so much promotes their increase in fat, and the appearance of their coats, some care would likewise be bestowed upon the ventilation of their stables—the consequent purity of the air which they are obliged to breathe. But this apparently reasonable anticipation is but rarely realized. On the contrary, we generally find that the unhealthiness of the atmosphere in which stabled horses and cattle are placed, increases with the value of the animal; this is especially the case with the horse. The groom finding no mode so easy in his endeavours to procure for his horses a fine coat, as that of keeping them in a high temperature, is pretty sure, if not restrained, to effect this by excluding from his stable every breath of air by which its temperature may be lowered, or its purity preserved. It results then (often, it is true, by slow degrees) that the animal from the breathing an atmosphere surcharged (as a certain consequence) with the carbonic acid gas emitted from the lungs of the horses in the stable, and with fumes of ammonia from the decomposing urine with which the floor is saturated (a decomposition accelerated by the warmth of the place) become tender and diseased. That to this source must be attributed the majority of those diseases of the lungs by which so many valuable horses are annually carried off, there is no reason to doubt. "The temperature of the stable," says Professor Youatt, in his excellent treatise on the horse, "should never in winter exceed ten degrees above that of the external air, and during the rest of the year should be as similar to it as possible." And he adds a fact which is far too little known to the owners

* *Supplementary Note for vol. i. p. 168 of "British Husbandry."*

of live stock: "The return to a hot stable is quite as dangerous as the change from a heated atmosphere to a cold and biting air. Many a horse that has travelled without injury over a bleak country, has been suddenly seized with inflammation and fever when he has immediately at the end of his journey been surrounded with heated and foul air." "And," he adds in another place, "of nothing are we more certain, than that in the majority of the maladies of the horse, those of the worst and most fatal character, directly or indirectly are to be attributed to the unnatural heat of the stable." The evil, then, being certain, the remedy merely consisting in the better and more *regular* ventilation of the stable, can I urge upon the horse's owner a more reasonable or a more profitable improvement than this? My own experience tells me, that a warm box, well ventilated and constantly kept clean, is by far the best and the most healthy medium in which a horse can be placed. Both *cleanliness* and ventilation must, of course, go together; for it is easy to lose the advantages of ventilation by a disregard to the cleanliness of the stable.

With regard to the stall-fed cow and the ox, the same erroneous mode of treatment is too constantly adopted: *warmth* and *quiet*, and an absence of light, it is true, have all been determined to be highly conducive to the rapid progress of the animal to maturity, but no sensible farmer ever yet concluded that the purity or the foulness of the air in which the animal is placed, is a matter of perfect indifference: and yet in how many instances are such cows, such fattening oxen, stall-fed, in an atmosphere in which the lungs of the animals *must* be weakened, their health endangered? How commonly do we see them placed in low close stables, into which a breath of fresh air rarely enters? It is idle to contend that to confine them in such an atmosphere does them no injury. It has been found that the same kind of impure air which these animals are too often made to endure, is *certain death* to the *smaller animals;* and, that the mortality increases as the size of the animal decreases, has been well shown by many curious and valuable inquiries. I will give a few only of these, being quite sure that to many of my readers they will afford matter of grave and useful reflection, when they are considering the ventilation not only of the stables of their live stock, but of the cottages of their labourers, and the rooms which the farmer is himself inhabiting. Let us commence our inquiries, then, with the effects of bad air upon the smaller tribes of birds, and proceed afterwards to the larger animals. "It is well known," says Dr. Arnott, (*Report of Commissioners upon the Health of Towns*, p. 61,) "that a canary bird suspended near the top of a curtained bedstead in which people have slept, will generally, owing to the impurity of the air, be found dead in the morning; and small, close rooms, in the habitations of the poor, are sometimes as ill-ventilated as the curtained bedstead."

Mr. Edwin Chadwick, the excellent Secretary to the Poor-Law Commissioners, in his able supplementary report upon the sanatory condition of the labouring classes, gives some striking facts in illustration of the ill effects of bad smells upon the health of small birds. He says, (p. 10,) "In the course of some inquiries which I made with Professor Owen, when examining a slaughterman as to the effects of the effluvia of animal remains on himself and family, some other facts were elicited illustrative of the effects of such effluvia on still more delicate life. The man had lived in Bear Yard, near Clare Market, which was exposed to the combined effluvia from a slaughter-house and a tripe factory. He was a bird fancier, but he found that he could not rear his birds in this

place. He had known a bird, fresh caught in the summer time, die there in a week. He particularly noted, as having a fatal influence on the birds, the stench raised by boiling down the fat from the tripe offal. He said, 'You may hang the cage out of the garret window, in any house round Bear Yard, and if it be a fresh bird it will be dead in a week.' He had previously lived for a time in the same neighbourhood, in a room over a crowded burial-ground in Portugal Street. At times, in the morning, he had seen a mist rise from the ground, and the smell was offensive. That place was equally fatal to his birds. He had removed to another dwelling-house in Vere Street, Clare Market, which is beyond the smell from this particular place, and he was now enabled to keep his birds. In town, however, the ordinary singing birds did not actually live more than about eighteen months. In cages, in the country, such birds were known to live as long as nine years or more, on the same food. When he particularly wished to preserve a pet bird, he sent it for a time into the country; and by repeating this removal he preserved them much longer. The fact of the pernicious effect of offensive smells on the small graminivorous birds, and the short duration of their life in close rooms and districts, was attested by a bird-dealer. In respect to cattle, the slaughterman gave decided reasons for the conclusion, that, whilst in the slaughter-house, they lost their appetites and refused food, from the effect of the effluvium of the place, and not, as was popularly supposed, from any presentiment of their impending fate."

That disease, and increased mortality from the effects of breathing an impure air, are not confined to very small animals, will be seen from the following extract from the evidence of Dr. N. Arnott, given in the first report of "the Commissioners for Inquiring into the Health of large Towns, and populous Districts," p. 52. He there observed, when speaking of a remarkable instance which occurred a year or two ago, serving to show the degree of knowledge which exists not only in the public at large, but amongst those from whom better things might, from their scientific attainments, be expected, that "in the Zoological Gardens, in the Regent's Park, a new house was built to receive the monkeys; and no expense was spared which, in the opinion of those entrusted with the management, could ensure to these natives of a warm climate all attainable comfort and safety. Unhappily, however, it was believed that the objects would be best secured by making the new room nearly what an English gentleman's drawing-room is. For warming it, two ordinary drawing-room grates were put in, as close to the floor as possible, and with low chimney openings, that the heated air in the room should not escape by the chimneys, while the windows and other openings in the walls above were made as close as possible. Some additional warm air was admitted through the openings in the floor from around hot-water pipes placed beneath it. For ventilation in cold weather, openings were made in the skirting of the room close to the floor, with the erroneous idea that the carbonic acid gas produced in the respiration of the animals, because heavier than the other air in the room, would separate from this and escape below. When all this was done, about sixty healthy monkeys, many of which had already borne several winters in England, were put into the room. A month after, more than fifty were dead, and the few remaining ones were dying. This room, open only below, was as truly an extinguisher to the living monkeys, as an inverted coffee-cup, held over and around the flame of a candle, is an extinguisher to the candle. Not only the warmth from

the fires, and the warm air allowed to enter by the openings in the floor, but the hot breath, and all the impure exhalations from the bodies of the monkeys, ascended first to the upper part of the room, to be completely incorporated with the atmosphere there, and by no possibility could escape except as a part of that impure atmosphere gradually passing away by the chimneys and the openings in the skirting; therefore, from the time the monkeys went into the room until they died, they could not have had a single breath of fresh air. It was necessary only to open, in the winter, part of the ventilating apertures near the ceiling, which had been prepared for the summer, and the room became at once salubrious. The day after I saw the monkey-house just mentioned, I was sent for to visit a young gentleman, at a respectable school in the neighbourhood of London, where there were about forty boys: the boy I went to see was thought to be falling into consumption, and I learned that others of the boys were also ill. On examination, I found the cause to be only a less degree of the error which had destroyed the monkeys. The two cases struck me forcibly, as illustrations of the little knowledge on the important subject of the essentials of health possessed by persons otherwise highly accomplished. A new school-room had been built at the back of the dwelling-house, in which room the forty boys spent much of their time, and there was no opening by which their breath could escape from the room, except through the *low* fire-place. There was, indeed, a skylight above with sashes, which might be opened; but the schoolmaster told me that he took care never to open these when the boys were present, because, having done it once, a boy got severe inflammation of the lungs in consequence of the cold air rushing in upon him. This gentleman had gone to a great expense to secure, as he thought, the health and comfort of his scholars; but from want of knowledge on the subject, had missed his aim, just as had happened in the case of the monkey-house."

How many a gallant horse is thus placed in his nearly air-tight stable, in a situation as much resembling an inverted coffee-cup as the monkeys of the Zoological Gardens! The fire of the monkey-house, it is true, is wanting: but how often is a *worse*, a more impure heat, produced by the horse or the cow being placed over a fermenting hotbed of dung? That our domestic animals become diseased from this source, that they are rendered less thriving, are considerations which too seldom present themselves to our notice; still less do we suspect the close connection which subsists between the *diseases of animals, their causes, and our own.* Mr. Chadwick notices these facts in his very able report. (*On the Sanitary Condition of the Poor*, p. 103.) He observes:—

"The spread of the knowledge of the fact that animals are subject to typhus, consumption, and the chief of the train of disorders supposed to be peculiarly human," remark the Commissioners in another place, "will, it may be expected, more powerfully direct attention to the common means of prevention." (*Report*, p. 103.) The following extract from a report on the labours of the Board of Health, at Paris, will show the effect of bad ventilation on cattle:—"The *epizootie* are, in many respects, less serious than the epidemics: nevertheless, as they often affect the animals which serve for the nutriment of man, and that, apart from this consideration, they may have grave consequences for the public health, they have constantly engaged the care of the Council. In 1834 an *epizootie* was reported to the Administration, which prevailed amongst the cows of the communes round Paris, and which caused a great mortality. The researches of the Council established that this

epizootie was only a chronic disease, a true pulmonary phthisis, to which has been given the name of *pommelière*, and by which the greater part of the cows had been attacked which fill the stables of the milkmen of Paris and its environs. According to the Council, the principal cause of the evil was to be attributed to the vicious regimen to which this animal is subjected. It is known that they pass a part of the year in stables perfectly closed, in which the space is not proportioned to the number of inmates, in which the vitiated air renews itself with extreme difficulty, and in which the heat is sometimes suffocating. It is known, also, that they pass suddenly from the food of the stable to pasture, and that in this change they go from the hot and humid atmosphere of the stable to a sudden exposure to the continued variations of the external air. This alternation of food, and of heat and cold, operates as a powerful cause of disease. But as the evil does not announce itself in a violent manner, as its progress is not very rapid, as there is even a period in the disease in which the animal is disposed to get flesh, the cow-feeder, who knows to what point to keep her, sells her when she is ready to calve. It is in a radius of thirty leagues from the capital that cows of this kind are purchased by the jobbers, who supply the milkmen of Paris. With these last they still hold out a certain number of years, if they are properly cared for; but in general they are kept in stables which are neither sufficiently large nor sufficiently airy, where they are exposed to the same causes which gave birth to the malady. The phthisis arrives insensibly at its last stage, and carries off every year, from Paris and its neighbourhood, a great number of these cows."

A similar discovery was only lately made as to the effect of defective ventilation on the cavalry horses in some of the government barracks in England; and it is stated that a saving of several thousand pounds per annum was effected by an easy improvement of the ventilation of the barracks near the metropolis. An agriculturist had a large number of sheep housed to feed them on mangel wurzel, but a great number of them sickened and died, and he supposed that it was the food which had killed them. A veterinary surgeon, however, who happened to be aware of the consequences of defective ventilation, pointed out the remedy—a better ventilation for the over-crowded sheep. The defect was remedied; the sheep throve well.

SECTION IX.

THE POTATO MURRAIN.

The Potato Murrain.—"By this name," says Mr. George W. Johnson, (*Gardener's Dictionary*, p. 517,) "was distinguished a moist gangrene, which attacked very generally the potato crop of England, late in the autumn of the year 1845. July and August in that season were unusually wet and cold, and early in August there were sharp morning frosts. Immediately after, the stems began to decay; but, the weather continuing wet, instead of their decay being dry and attended with the usual phenomena of their reduction to mere woody fibre, the putrefaction was moist, and the smell attendant upon it precisely that evolved during the decay of dead potato haulm partly under water. The stem decayed whilst the fibres connecting the tubers with them were fresh and green; the putrefaction spread along these, the ichor being absorbed by their still energetic vessels, and passing into the still immature and unusually

juicy tubers, imparted to them the gangrene. The infection first being apparent at the end nearest the connecting fibre, spreading gradually throughout the liber of the tuber, rendering it brown like a decayed apple, and lastly causing the decay of its interior portion. Previously to the final decay, the increased specific gravity of the potato was remarkable, amounting to one-third more than that of a healthy potato, an increase caused by its greater amount of water. When boiled it became black, but when submitted to a dry heat of about 200°, it rapidly lost moisture, and the progress of the ulceration was retarded if not entirely stopped." And as I have had occasion to observe in another place, (*Farmer's Mag.* vol. xxiv. p. 285,) so clearly have these facts been established, that many very true friends of their country have zealously commenced an inquiry as to the best substitute in our possession for this extensively employed root. The Dean of Westminster has pretty well directed our attention to the most easily available of these, in case of the absolute failure of the potato. (*Farmer's Magazine,* vol. xxiv. p. 19.) They consist of pea-meal, barley-meal, and oat-meal; and, as Dr. Buckland observes, pea-meal was the staple food throughout Europe, before the introduction of potatoes. "Let us," he says, "for a part of this and next year, for once live as they lived three hundred years ago." Barley-meal, mixed with other flour, or eaten with other kinds of food, (for it is too heating by itself,) is very nourishing. Oat-cake is the bread of all Scotland, and of a great portion of Ireland and the north of England.

It is almost fruitless to inquire into the origin of the disease or its cure, for we are only rewarded by increasing doubts and difficulties. Dr. Lyon Playfair, in his able lectures on the nature and causes of the disease in potatoes, has collected together nearly all the valuable facts hitherto noted on these heads. The proportion of water in the diseased potato is certainly more considerable than in the healthy specimen. Dr. Playfair obtained the following results from his experiments:—

Variety of Potato.	Contained Water.	
	Healthy.	Diseased.
Keswicks	75.3	80.7
„	75.5	81.3
York reds	72.8	79.0
„	67.3	74.7
Kidneys	71.4	75.7
Shaws	72.1	83.0

That the disease is not new to the potato is certain. "It must have existed," says Dr. Playfair, "ever since the potato itself;" and M. Boussingault informs us that at Bogota, in America, where the plant is indigenous, the disease has been long known; so long that the Indians do not know of its being introduced. It has been attributed, amongst other causes, to too much rain, in 1845; too little sun; to the exhaustion of the potato species by very long continued croppings; to the peculiar electrical state of the atmosphere; and to the effect at length produced (and this seems to me as the most reasonable suggestion of the many) by digging up the potatoes in the autumn, and keeping them half the year in pits and other places foreign to the natural habits of the plant.

The best practical remedy for the disease in future, and for the security of the present crop, is a far more important consideration. On this, a valuable little tract, by my brother, Mr. George W. Johnson,

made its appearance in 1846; and, after having carefully compared his experiments and observations with my own, I am led to the conclusion that the treatment he suggests is by far the most certain of success of any that have been hitherto proposed. He says, "The remedy is very simple; and, as is usually the case, is preventive rather than curative, viz.:—*Plant at the close of September, or in the first week of October.* Last year, I planted at the latter period, every variety, both early and late, which I cultivate; walnut-leaved, ash-leaved, Julys, and red-nosed kidneys; and they all have yielded crops so free from disease, that my gardener has not detected a peck of ulcerated tubers among all those taken up as they have been required. But other crops of the same varieties, planted in the spring of the present year, are extensively diseased and much less productive. A plot of Cornish kidneys, which I obtained direct from Penzance, particularly clear and sound, and planted in the spring of this year, produced plants not only having half their tubers ulcerated, but their leaves much curled; and the produce consequently is very small. I planted last October some tubers which were literally masses of rottenness, but each having some eyes prominently vegetated, and attached to small portions of the liber yet undecayed. My gardener observed to me this day, (August 28th,) that the produce of these is as healthy as that from untainted sets planted at the same time. I directed him to take up the two first roots we came to, and the produce from these was no less than twenty-seven potatoes, weighing in the aggregate 16 lbs. 13¼ oz. Of these, seventeen tubers were quite large enough for table use. This will be readily perceived by the following table, showing the respective weights of the tubers:—

1	tuber weighed	. . . . . .	12¼	oz.
3	" "	(each 8¾ oz.)	26¼	"
1	" "	. . . . . .	8¼	"
1	" "	. . . . . .	7¼	"
1	" "	. . . . . .	6½	"
1	" "	. . . . . .	6	"
1	" "	. . . . . .	5¼	"
8	" "	. . . . . .	23¾	"
10	" "	. . . . . .	13½	"
27			109¼	oz. = 16 lbs. 13¼ oz.

"Mr. J. Smeed, of Bromston, in the Isle of Thanet, though no friend to early planting for the main crop, admits that, in 1845, 'the early potatoes escaped almost unhurt in many localities.' (*Gard. Chron.* p. 501.) Mr. E. Compton, of Water Newton, near Wansford, states that ash-leaved potatoes, planted in October and November, gave a crop perfectly free from disease, and every way better than that from sets put in during the March of this year. (*Ibid.* p. 518.) Mr. H. B. Mason, in Dorsetshire, and another party in Norfolk, agree that 'the autumn-planted have escaped, whilst those planted in spring have been affected.' (*Ibid.* p. 533.) Mr. Barnes, the highly intelligent gardener at Bicton Gardens in Devonshire, though he does not think autumn-planting a specific against the disease, says, in a letter now before me, dated August 24th of the present year, 'We have had astonishing crops of potatoes this season from the autumn-planted, and what we have left in store keep very well in charred matters.'"

Treatment of Crops.—Allow the crops of all varieties to remain undisturbed until the close of September; and then, the earlier the better,

take up so many as will afford a sufficient number of middling-sized tubers for planting for next year's crop. By middling-sized, I mean such as weigh from 2 oz. to 3 oz. each. Keep these out of the ground not an hour longer than is unavoidable. I recommend the crop to be taken up no faster than the ground is ready for immediately planting the middling-sized tubers. Dig just enough ground for one row, and then plant with a dibble, without treading on the newly dug soil, that it may lie as loosely as possible over the sets, for its being well permeated by the air is an additional security against the penetration of frost, air being one of the worst conductors of heat, and consequently the best excluder of cold, which is no more than an abstraction of heat. Plant six inches deep, twelve inches apart in the rows, and the rows eighteen inches apart. No frost, however severe, will injure them at that depth, if the soil is not clayey or wet. If it be either clayey or wet, then drop in a handful of coal ashes over each set. The autumn-planted crop will appear later above ground than the spring-planted. Keep the plants well hoed, but do not earth them up. The haulm, both foliage and stem, will be quite dead early in August. In 1846, it was completely dead and dry by the 14th, in crops of Julys and red-nosed kidneys planted last October.

The potatoes necessarily taken up when getting those required for seed, store away in the coldest place at command, and in earth or coal ashes. But if the space be not required for other crops, let the potatoes remain in the ground where grown, to be taken up as required. The only precaution necessary is to clear away the weeds and refuse, and with a hoe to draw up the earth so as to form a ridge three or four inches additionally deep over each row. As required, a fortnight's consumption may be taken up at a time during any open weather in winter.

SEED *.

Considerable attention has been paid within the last few years to the improved amount of seed. This has chiefly arisen from the exertions of Mr. Hewitt Davis, who, if he has not succeeded in convincing the farmer of the advantage of employing on all soils diminished proportions of seed, has at least produced general good by drawing attention to the subject. The proportions of seed which he so successfully employs, are

Oats, 7 pecks, in Jan., Feb., and March.
Barley, 6 pecks, in Jan., Feb., March, and April.
Wheat, 3 pecks, in Sept. and Oct.
Peas, 8 pecks, in Dec., Jan., and Feb.
Beans, 8 pecks, in Sept. and Oct.
Rye, 1½ bush., in Aug. and Sept.
Tares, 1½ bush., (in 3 sowings,) in Aug., Sept., and Oct.
Mangel-wurzel, 6 lbs., in April.
Swedes, 1 quart, in May.
Turnips, 1 quart, in July.
Cabbages, 1 every 3 feet, in June.

* *Supplementary Note to "British Husbandry," vol.* ii. *p.* 88.

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